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**SEPTEMBER, 1916**

**No. 7.**

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**OF THE**  
**BOSTON SOCIETY**  
**OF**  
**CIVIL ENGINEERS**



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BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

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PROCEEDINGS

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NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, SEPTEMBER 20, 1916,

at 8 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Mr. Eugene E. Pettie will present a paper entitled, "The Construction of the Portland Bridge." The paper will be illustrated with lantern slides.

S. E. TINKHAM, *Secretary*.

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PAPERS IN THIS NUMBER.

"The Commercial Fertilizer Industry in the United States,"  
Lester W. Tucker.

"The Sewage Disposal Problem Confronting the City of Philadelphia," W. L. Stevenson.

"A Method of Transforming Latitude and Longitude into Plane Coördinates," S. H. Thorndike.

Discussion of "Pan-American Use of the Metric System."

Discussion of "Reform and Regulation."

Reprints from this publication, which is copyrighted, may be made provided full credit is given to the author and the Society.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

**PREPAREDNESS PARADE,**

MAY 27, 1916.

THE BOSTON SOCIETY OF CIVIL ENGINEERS was represented in the Preparedness Parade by about sixty members, forming two companies of two platoons each, led by a marshal and staff officers. Many members of the Society marched in other sections of the engineers' division.

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**MINUTES OF MEETING.**

HULL, MASS., June 21, 1916. — A regular meeting of the Boston Society of Civil Engineers was held this afternoon at the Pemberton Inn at the close of the shore dinner which was served in connection with the Joint Field Day and Excursion of the New England Water Works Association and this Society.

The meeting was called to order by the President, Richard A. Hale, at 3 o'clock. There were present 193 members and guests, including members of the Water Works Association and ladies.

By vote, the record of the May meeting was approved as printed in the June JOURNAL.

The President announced the election by the Board of Government of Mr. John P. Cyr as a member of the Society.

Prof. Alfred E. Burton brought to the attention of the meeting, the work of the Committee to Expedite the Completion of the Topographic Map of the United States. He stated that although the appropriations made by Congress have been liberal, and although topographic mapping has been industriously prosecuted by the United States Geological Survey for the past thirty-five years, so great is our national domain, that up to last July only 40 per cent. of its area had been represented on published maps, and at that rate of progress, about one hundred years will be needed to complete the map. He urged all who are interested in the matter to write to the Director of the United States Geological Survey, stating the practical uses that they make of the published maps and the value that they attach to them.\*

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\* See further statement by Professor Burton printed in this number of the JOURNAL.



The President then introduced Rear-Admiral Robert E. Peary, who addressed the Society on National Preparedness.

After passing a vote of thanks to Admiral Peary for the interesting and instructive address which he had given, the Society adjourned.

S. E. TINKHAM, *Secretary*.

BOSTON, MASS., June 7, 1916. — The regular June meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening in the Society Library, Tremont Temple.

The meeting was opened at 7.45 o'clock with Chairman Frederic Bonnet, Jr., presiding. The minutes of the May meeting were read and approved.

The chairman then introduced Mr. W. L. Stevenson, assistant engineer in charge, Sewage Disposal, Philadelphia, Pa., who presented a paper on "The Sewage Disposal Problem Confronting the City of Philadelphia." Mr. Stevenson described briefly, with the aid of lantern slides, the plan adopted for the collection, treatment and disposal of the sewage of the city at three main disposal works. He also described in considerable detail the design and form of construction of the Frankford Creek Intercepting Sewer. Many details were discussed which were of particular interest to members present who have to design sewerage works and, especially, regulating devices. Considerable interest was shown by all, and, taking all matters into consideration, the meeting proved to be one of the best held for some time.

It was voted to extend a rising vote of thanks to Mr. Stevenson for his courtesy in presenting the paper and explaining so many details.

There were 46 present. Adjourned at 9.25 o'clock.

FRANK A. MARSTON, *Clerk*.

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## APPLICATIONS FOR MEMBERSHIP.

[September 5, 1916.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the

eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

BELL, FRANK CHARLES, Malden, Mass. (Age 42, b. Somerville, Mass.) Educated in public schools; graduate of Malden High School, 1892. From 1892 to 1898, with late W. H. Whitney, Boston, on municipal surveying; from 1898 to date, with Boston Elevated Ry. Co.; is now assistant engineer, department of Maintenance of Way. Refers to L. S. Cowles, B. W. Ellis, H. C. Hartwell and A. L. Plimpton.

DELANO, RAY OSBORN, Boston, Mass. (Age 23, b. North Duxbury, Mass.) Student at Mass. Inst. of Technology for three years; graduate of Lowell Inst. School for Industrial Foremen, 1916, buildings course. Refers to H. W. Hayward, G. L. Hosmer, W. H. Lawrence and A. G. Robbins.

WADE, WM. NEWELL, Boston, Mass. (Age 45, b. Easton, Mass.) Graduate of North Easton High School, 1888. From Nov., 1888, to April, 1892, on land survey; from April to July, 1892, on street railway location; from July to Nov., 1892, with the City of Brockton on sewerage system; from Nov., 1892, to July, 1893, with B. & M. R. R., on track locations; from July, 1893, to July, 1900, assistant to roadmaster with N. Y., N. H. & H. R. R., Maintenance of Way Dept.; from Aug., 1900, to April, 1901, with Boston Elevated Ry. Co., as steel inspector on elevated construction; from April, 1901, to July, 1915, assistant engineer with Mass. Highway Commission; from July, 1915, to Feb., 1916, first assistant engineer with Coleman du Pont Road, Inc., Georgetown, Del.; from April, 1916, to date, with Mass. Highway Commission. Refers to A. B. Appleton, C. L. Brown, A. W. Dean, A. M. Lovis, F. H. Morris and C. H. Restall.

YOUNG, ERVING MANDEVILLE, Waterbury, Conn. (Age 27, b. Haverhill, Mass.) Graduate of Mass. Inst. of Technology, 1911, civil engineering



course. Since that time has been engaged chiefly in inspection of concrete and heavy timber construction for Monks & Johnson, Stone & Webster Engrg. Corp'n and Aberthaw Construction Co.; was employed by last-named company as efficiency and cost expert on ten concrete buildings for Winchester Arms Co., New Haven, Conn., and two for Pierce Arrow Motor Co. at Buffalo, N. Y.; was in charge of inspection for Stone & Webster on one half of new Technology buildings; is now engineer in charge of outside construction of concrete building for Chase Metal Works, Waterville, Conn. Refers to L. H. Allen, J. A. Garrod, Mark Linenthal, C. G. Richmond and C. M. Spofford.

## LIST OF MEMBERS.

### ADDITIONS.

|                       |                                   |
|-----------------------|-----------------------------------|
| COBURN, FRANK R.....  | Watertown, Mass.                  |
| CYR, JOHN P.....      | 10 Hartshorn Ave., Nashua, N. H.  |
| HANNAH, THOMAS E..... | 70 Congress St., Fitchburg, Mass. |
| HOLMES, HARRY E.....  | 115 Walnut St., Malden, Mass.     |

### CHANGES OF ADDRESS.

|                             |                                                                 |
|-----------------------------|-----------------------------------------------------------------|
| ALBEE, EDWARD E.....        | 24 Prospect St., Weymouth, Mass.                                |
| BIGELOW, WILLIAM W.....     | 624 State St., Springfield, Mass.                               |
| CASHMAN, JOHN M.....        | 60 Beechwood Ave., Watertown, Mass.                             |
| COWLES, M. WARREN.....      | 426 W. Munroe St., Springfield, Ill.                            |
| CROSS, RALPH U.....         | 130 Burncoat St., Worcester, Mass.                              |
| CURTIS, ALLEN.....          | 21 Lexington Ave., W. Somerville, Mass.                         |
| DE LA HAYE, ELIAS, Jr.....  | 25 Glendale St., Dorchester, Mass.                              |
| FEHR, GORDON.....           | 5704 Baum Blvd., Pittsburgh, Pa.                                |
| FLAWS, JAMES B.....         | 3 Newbridge Ave., North Woburn, Mass.                           |
| FOSTER, HOWARD L.....       | 102 Huntington Ave., Boston, Mass.                              |
| GREEN, HOWARD W.....        | 383 South Main St., Woonsocket, R. I.                           |
| HAYWARD, EDWIN D.,          |                                                                 |
|                             | Dept. of Civil Engrg., University of California, Berkeley, Cal. |
| MORRISON, HARRY J.....      | Mullens, W. Va.                                                 |
| NOLAN, CONRAD.....          | 2 Curtis Ave., Tufts College, Mass.                             |
| PEACOCK, FRANK E.....       | 623 N. Church St., Rockford, Ill.                               |
| PETTEE, EUGENE E.....       | 79 Milk St., Boston, Mass.                                      |
| POWERS, WILLIAM J., Jr..... | 130 Mt. Pleasant Ave., Roxbury, Mass.                           |
| REILLY, L. BAYLES.....      | 602 City Hall Annex, Boston, Mass.                              |
| SIMONS, GEORGE W., Jr.....  | Jacksonville, Fla.                                              |
| SNOW, LESLIE W.....         | Rochester, N. H.                                                |
| WIRES, HARRISON P.....      | 47 Broadway, Rockport, Mass.                                    |
| WOLFE, CHRISTIAN F.....     | Y. M. C. A., 404 East 10th St., Kansas City, Mo.                |

### EMPLOYMENT BUREAU.

THE Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

#### MEN AVAILABLE.

No. 365. Age 22. Student for three years in engineering department, Tufts College. Has had one year's experience as timekeeper and foreman on concrete work. Salary desired, \$10 per week.

No. 367. Age 19. Student for one year at Harvard University. Has had no practical experience. Desires to start in office or with party in field.

No. 370. Age 30. Educated in public schools, including high school. Experience consists of nine years with consulting engineers, during which time he has served in various capacities, from office boy to resident engineer; work has been chiefly on water works and sewerage. Desires position with contractor or field work with engineer.

No. 371. Age 32. Received education at technical and evening schools. Has had fourteen years' experience, including three years with railroad corporation, two as draftsman in Bridge Dept. and one as rodman and transitman in Construction Dept.; five years with private engineering and contracting concerns as draftsman, designer and estimator on structural steel and concrete work; and six years with large corporation as draftsman and assistant engineer in charge of designs for storehouses, rendering plants, etc. Desires position with live engineering firm as assistant engineer, or with a contracting firm as engineer and estimator. Salary desired, \$2 500 per year.

No. 372. Age 20. Educated in public and private schools, including high school. Is without experience, but is good at lettering. Desires work as tracer, preferably with architect.

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### COMPLETION OF THE TOPOGRAPHIC MAP OF THE UNITED STATES.

Prof. Alfred E. Burton, Secretary of the Committee to Expedite the Completion of the Topographic Map of the United



States, has submitted the following statement in relation to the completion of the map:

A committee made up of prominent civil and hydraulic engineers, foresters, highway commissioners and business men, has been organized with the intention of urging the speedy completion of a topographical map of the United States. They are sending out a circular to all engineers who they think would be interested in this project, and are inviting them to write to the secretary of their committee a letter which the committee can be authorized to use later in making a statement of the case to the appropriate congressional committee. In their circular there is this statement in regard to the present state of the map:

A standard topographical map of the entire area of the United States based on official surveys has been in preparation by the United States Geological Survey since 1880, and although the survey has been industriously prosecuted, and although the appropriations made by Congress have been liberal, up to July 1, 1915, only 40 per cent. of our domain has been represented on published topographical maps. The rate of progress since 1905 has been very much slower, and the rate has been practically steady during the past ten years. If this rate is not accelerated, the whole country will not be surveyed for one hundred years.

Progress towards its completion must be expedited, especially for a belt of country several hundred miles inland from all our coasts and frontiers. For this, an annual increase in the appropriation for a topographical map should be made for five or ten years to come.

Various corporations, commissions and individuals are invited to state the practical uses that they make of the published maps, and the value that they attach to them, and to send a copy of their statements to the Director of the United States Geological Survey and to the secretary of this committee. Statements to the same effect will be requested from various interested organizations, such as engineering societies, state academies of science, geological and geographical societies, automobile and mountaineering clubs, etc. This committee will prepare a statement based on the testimony thus secured as to the practical value of the topographical maps now published, the need of maps in

unsurveyed areas, the need of larger-scale maps for areas already published on a smaller scale, and the need of the revision of all maps with respect to new cultural features. This statement will then be submitted to the appropriate committee of Congress.

A partial list of the questions which the committee would like answered is appended:

Have you found the maps useful in railway engineering?  
 in highway engineering?  
 in forest surveys?  
 in irrigation projects?  
 in drainage projects?  
 in soil surveys?  
 in water-power projects?  
 in electrical transmission lines?  
 in prospecting in mining?  
 in publishing?  
 in teaching?

They would also like to have statements from individuals of specified examples of the manner in which published maps have aided their work, and how work might have been facilitated in unsurveyed regions if the maps had been available. They also invite criticism and would like to have it stated in what respects are the published maps insufficient for engineering needs. Is their scale too small; have they been found inaccurate?

Very truly yours,

ALFRED E. BURTON, *Secretary of the Committee.*

The following is the membership of the Committee to Expedite the Completion of the Topographical Map of the United States:

W. M. Davis, chairman, professor of geology, emeritus, Harvard University, Cambridge, Mass.; A. E. Burton, secretary, dean, Massachusetts Institute of Technology, Cambridge, Mass.; Robert Bacon, president National Security League, New York; Arthur H. Blanchard, consulting engineer National Highways Association, professor of highway engineering, Columbia University, New York; G. P. Coleman, state commissioner of highways, Richmond, Va.; G. E. Condra, president National Conservation Congress, State University, Lincoln, Neb.; W. L. Darling, chief engineer Northern



Pacific Railway Co., St. Paul, Minn.; R. E. Dodge, president National Council Geography Teachers, Teachers' College, New York; A. B. Fletcher, state highway engineer, Sacramento, Cal.; W. Cameron Forbes, of J. M. Forbes & Co., Boston, Mass.; John R. Freeman, consulting engineer, Providence, R. I.; W. O. Hotchkiss, state geologist, Madison, Wis.; F. H. Newell, professor of civil engineering, University of Illinois, Urbana, Ill.; Joseph H. Pratt, state geologist, Chapel Hill, N. C.; Wm. Barclay Parsons, consulting engineer, New York; Charles A. Stone, of Stone & Webster, Boston, president International Corporation, New York; Frank M. Williams, state engineer, Albany, N. Y.

## LIBRARY NOTES.

### BOOK REVIEW.

THE AMERICAN ROAD, by James I. Tucker, professor of civil engineering, University of Oklahoma; for sale by The American Road, Norman, Okla., 1916. Cloth, 5 in. by 7 in., 235 pages, 39 illustrations, 15 tables. \$1.08.

*Reviewed by Arthur W. Dean.*

While, as the author states on the title-page, this is a "non-engineering manual for practical road builders," it nevertheless contains much matter of interest to the engineer, and of special value to the young graduate civil engineer, who has given little attention to matters most characteristic and vital in highway work. It presents, in clear and concise language, simple facts which are essential in road building. Fifteen chapters, covering 228 pages, describe in non-technical language the problems of the road builder, including, besides methods and materials, the economics, proper organization, the needed legislation and the many other major and minor matters constantly open for discussion by those interested in the subject.

In describing construction methods and materials, the author gives very general descriptions, giving considerable space to gravel and other cheap types of roads, but little direct information on more permanent types of roadways.

The book is quite valuable for the main purpose for which it was prepared, viz., to use in connection with correspondence instruction, in which use it will tend to encourage study and thought on road construction.

## RECENT ADDITIONS TO THE LIBRARY.

**U. S. Government Reports.**

Abrasive Materials in 1915. Frank J. Katz.

Annual Report of Chief of Weather Bureau for 1914-15.

Automobile Registrations, Licenses, and Revenues in United States, 1915.

Retreat of Barry Glacier, Port Wells, Prince William Sound, Alaska, between 1910 and 1914. Bertrand L. Johnson.

Revision of Beckwith and Bear River Formations of South-eastern Idaho. G. R. Mansfield and P. V. Roundy.

Caddo Oil and Gas Field, Louisiana and Texas. George Charlton Matson.

Strength and Other Properties of Concretes as Affected by Materials and Methods of Preparation. R. J. Wig, G. M. Williams and E. R. Gates.

Cotton Production in United States, Crop of 1915.

Fauna of Chapman Sandstone of Maine. Henry Shaler Williams.

Feldspar in 1915. Frank J. Katz.

Flora of Fox Hills Sandstone. F. H. Knowlton.

Fluorspar in 1915. Ernest F. Burchard.

Arguments For and Against Limitation of Length of Freight Trains.

Fuller's Earth in 1915. Jefferson Middleton.

Contributions to Economic Geology, 1915. Part I.—Metals and Non-Metals except Fuels. F. L. Ransome and Hoyt S. Gale.

Geology and Coal Resources of Castle Valley, Utah. Charles T. Lupton.

Geology and Underground Water of Luna County, New Mexico. N. H. Darton.

Gold, Silver, Copper, Lead, and Zinc in Eastern States in 1915. James M. Hill.

Graphite in 1915. Edson S. Bastin.

Experiments on Economical Use of Irrigation Water in Idaho. Don H. Bark.

Determination of Difference in Longitude between Each



Two of Stations Washington, Cambridge, and Far Rockaway. Fremont Morse and O. B. French.

Results of Magnetic Observations Made by United States Coast and Geodetic Survey in 1915; Results of Observations Made at United States Coast and Geodetic Survey Magnetic Observatory at Sitka, Alaska, 1913 and 1914; Results of Observations Made at United States Coast and Geodetic Survey Magnetic Observatory at Vieques, Porto Rico, 1913 and 1914. Daniel L. Hazard.

Some Manganese Mines in Virginia and Maryland. D. F. Hewett.

Mineralogic Notes: Series 3. Waldemar T. Schaller.

Relation of Wissahickon Mica Gneiss to Shenandoah Limestone and Octoraro Schist of Doe Run and Avondale Region, Chester County, Pennsylvania. Eleanor F. Bliss and Anna I. Jonas.

National Parks Portfolio.

Ozokerite in Central Utah. Heath M. Robinson.

Physical Conditions and Age Indicated by Flora of Alum Bluff Formation. Edward Wilber Berry.

Physical Conditions Indicated by Flora of Calvert Formation. Edward Wilber Berry.

Portland Cement Materials and Industry in United States. Edwin C. Eckel.

Petroleum Withdrawals and Restorations Affecting Public Domain. Max W. Ball.

Experiments on Extraction of Potash from Wyomingite. Roger C. Wells.

Primary Traverse in Alabama and North Carolina, 1913-15. R. B. Marshall.

Railway Stockholders, June 30, 1915.

Results of Physical Tests of Road-building Rock. Prévost Hubbard and Frank H. Jackson, Jr.

Sand-lime Brick in 1915. Jefferson Middleton.

Silica in 1915. Frank J. Katz.

Spirit Leveling in Louisiana, 1903 to 1915, inclusive; Spirit Leveling in Maine, 1899-1915; Spirit Leveling in West Virginia,

1896 to 1915, inclusive; Triangulation in Arizona and New Mexico, 1913-15. R. B. Marshall.

Water-Supply Papers 383 and 398.

Measuring and Marketing Woodlot Products. Wilbur R. Mattoon and William B. Barrows.

### State Reports.

Connecticut. Annual Report of Public Utilities Commission for 1915.

Maine. Annual Report of Public Utilities Commission for 1915, Vol. II.

Massachusetts. Annual Report of Harbor and Land Commissioners for 1915.

Massachusetts. Annual Report of Highway Commission for 1915.

Massachusetts. Annual Report of Metropolitan Park Commissioners for 1915.

Massachusetts. Annual Report of Metropolitan Water and Sewerage Board for 1915.

Massachusetts. Annual Report of State Board of Health for 1914.

Massachusetts. Proceedings of Third Annual City and Town Planning Conference of Massachusetts Planning Boards, 1915.

Massachusetts. Report of State Department of Health and Municipal Council of City of Lynn upon Plan for Disposal of Sewage in City of Lynn.

Michigan. Investigation into Causes of Typhoid Fever Epidemic at Monroe, Michigan, 1915.

New Hampshire. Biennial Reports of State Department of Highways for 1909-14.

New Jersey. Annual Report of Department of Conservation and Development for 1915.

New York. Public Service Commission for First District: Map Showing Routes and Stations on Dual System. Gift of H. S. Knowlton.

Ohio. Annual Report of State Board of Health for 1914.



Rhode Island. Annual Report of Public Utilities Commission for 1915.

Wisconsin. Physical Geography of Wisconsin. Lawrence Martin.

### Municipal Reports.

Albany, N. Y. Annual Report of Bureau of Water for 1915.

Boston, Mass. Boston's Streets, 1916.

Boston, Mass. City Planning Board: Annual Report for 1915; East Boston, a Survey and Comprehensive Plan; Summary of Market Situation in Boston.

Boston, Mass. Reports of Finance Commission for 1914 and 1915.

Brockton, Mass. Annual Report of City Engineer for 1915.

Cambridge, Mass. Annual Report of City Engineer for 1914.

Erie, Pa. Annual Report of Commissioners of Water Works for 1915.

Fall River, Mass. Annual Report of City Engineer for 1915.

Gloucester, Mass. Annual Report of Water Commissioners for 1915.

Haverhill, Mass. Annual Report of City Engineer for 1915.

Haverhill, Mass. Annual Report of Water Commissioners for 1915.

Holyoke, Mass. Water Rates, Rules, etc., 1915.

Marlborough, Mass. Annual Report of Water and Sewage Commission for 1915.

New Orleans, La. Semi-annual Report of Sewerage and Water Board, December, 1915.

Newton, Mass. Annual Report of Street Commissioner for 1915.

Northampton, Mass. Annual Reports of City Officers for 1915.

Revere, Mass. Annual Report of Public Works Department for 1915.

Somerville, Mass. Annual Reports for 1915.

Waltham, Mass. Annual Report of City Engineer for 1915.

Wilmington, Del. Annual Reports of Water Commissioners for 1911-12 to 1914-15.

Woburn, Mass. Annual Report of Department of Public Works for 1915.

Woonsocket, R. I. Annual Report of Water Commissioners for 1915.

### Miscellaneous.

Abolish the Fahrenheit Thermometer. Hon. Albert Johnson.

American Electric Railway Association. Studies in Cost of Urban Transportation Service. F. W. Doolittle. Gift of H. S. Knowlton.

Canada. Department of Mines: Preliminary Report on Mineral Production of Canada for 1915, by John McLeish; Description of Laboratories of Mines Branch of Department of Mines, Ottawa; Investigation of Reported Discovery of Phosphate in Alberta, by Hugh S. de Schmid; Annual Report on Mineral Production of Canada during 1914, by John McLeish; Investigation of Peat Bogs and Peat Industry of Canada, 1913-14, by Aleph Anrep.

Planning of Modern City. Nelson P. Lewis.

Design and Construction of Dams. 6th ed. Edward Wegmann.

Engineer in War. P. S. Bond.

Highway Bridge Floors. Charles M. Spofford. Gift of author.

International Engineering Congress, 1915. Transactions: Waterways and Irrigation; Railway Engineering; Materials of Engineering Construction; Metallurgy; Miscellany.

Metallurgy of Iron and Steel. Bradley Stoughton.

National Board of Fire Underwriters: Shingle Roofs as Conflagration Spreaders; Special Report on Conflagration, March 22 and 23, 1916, Augusta, Ga.; Special Report on Conflagration of March 21, 1916, Paris, Tex.; Reports on following cities: Baltimore, Md.; Binghamton, N. Y.; Cambridge, Mass.; Canton, Ohio; Charleston, W. Va.; Chicago, Ill.; Council

Bluffs, Ia.; Elizabeth, N. J.; Evanston, Ill.; Green Bay, Wis.; Huntington, W. Va.; Joliet, Ill.; Kansas City, Kan.; Kansas City, Mo.; Meridian, Miss.; Milwaukee, Wis.; Montgomery, Ala.; Muskogee, Okla.; Nashville, Tenn.; Oklahoma City, Okla.; Oshkosh, Wis.; Philadelphia, Pa.; Portsmouth, Va.; Racine, Wis.; Roanoke, Va.; Rockford, Ill.; Savannah, Ga.; Sheboygan, Wis.; Sioux City, Ia.; Somerville, Mass.; Tulsa, Okla.; Wheeling, W. Va.

National Lumber Manufacturers Association: Heavy Timber Mill Construction Buildings. C. E. Paul.

Patents and How to Obtain Them. Watson E. Coleman.  
Profitable Inventions. Watson E. Coleman.

Direct-acting Steam Pumps. Frank F. Nickel.

Extent to which Sewage can be Purified by Practical Methods of Artificial Treatment Now in Use. Harrison P. Eddy.  
Gift of author.

United Shoe Machinery Co.; Efficiency through Hygiene;  
Story of Three Partners: Good Sport, Good Health, Good Work.

Fundamental Principles of Public Utility Valuation. John W. Alvord. Gift of author.

Water-works Handbook. Alfred Douglas Flinn, Robert Spurr Weston and Clinton Lathrop Bogert.

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The Society is indebted to Mr. Harrison P. Eddy for a subscription to the *American Journal of Public Health*, and to Mr. Desmond FitzGerald for a considerable number of books and pamphlets not as yet listed.

A member of the Society wishes to obtain a copy of "One Hundred and Fifteen Experiments on Carrying Capacity of Large Riveted Metal Conduits," by Clemens Herschel, which book is now out of print. He would appreciate information as to where a copy can be purchased.

LIBRARY COMMITTEE.



**NEW ENGINEERING WORK.**

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before 1st of each month.)

**United States Government.** — NAVY DEPARTMENT. — *Navy Yard, Boston.* — The yard railroad system is being reconstructed.

**Commonwealth of Massachusetts.** — METROPOLITAN PARK COMMISSION. — The following work is in progress:

*Alewife Brook Parkway.* — Surfacing and finishing Alewife Brook Parkway, from Massachusetts Ave. to Powder House Boulevard.

*Charles River Reservation.* — Building reinforced concrete bridge over the Charles River at North Beacon St., Boston and Watertown. A. G. Tomasello, contractor.

Building reinforced concrete bridge over the Charles River at Commonwealth Ave., Newton and Weston. T. Stuart & Son Company, contractor.

*Furnace Brook Parkway.* — The construction of parkway extension from Quincy Shore Reservation to Hancock St. John Cashman & Sons Company, contractor.

*Old Colony Parkway.* — Plans are being prepared for bridge over the Neponset River, Boston and Quincy, to replace old wooden bridge.

*General.* — Road surfaces in all divisions are being repaired.

**Boston Transit Commission.** — The Dorchester Tunnel has been practically completed from its beginning at Tremont St. for about 6 600 linear feet to a point under Dorchester Ave. in South Boston, near Broadway. There is, however, some work being done at the shaft in West First St. in connection with stairways for an emergency exit and a ventilating chamber.

Work is progressing on the Broadway Station, which extends

in Dorchester Ave. from Broadway to West Fourth St. The T. A. Gillespie Co. is the contractor.

Work on Section G, which extends in Dorchester Ave. from West Fourth St. to Old Colony Ave., is in progress. Coleman Brothers are the contractors.

Section H and Section H Extension, which are completed, extend from Old Colony Ave. to near Dexter St.

The next section, Section J, extending from a point near Dexter St. in a southerly direction in and near Dorchester Ave. and Boston St. to near Ralston St. and embracing the station in Andrew Sq., is being constructed. The T. A. Gillespie Co. is the contractor.

**Boston Elevated Railway Co. — *Everett Extension.*** — Work on the Everett Extension is proceeding at the bridges (Malden Bridge and the new Mystic River Bridge), which are under contract to the Hugh Nawn Contracting Company.

On the Mystic River Railway Bridge, four of the river piers are completed and all of the smaller foundations for the viaduct north of the bridge proper and as far as the old almshouse are completed. Work is under way on the four deep channel piers. Bottoms of these piers are to be thirty feet below low water, and steel sheeting for the cofferdam of the main pier is being driven at the present time.

On the reconstruction of the Malden Bridge, the portion south of new draw and north of the present draw opening is partially completed, floor planking being in place and the waterproofing and paving under way. North of the new draw the retaining wall on the lines of the street as relocated has been commenced.

**New York, New Haven & Hartford R. R. Co. —** It is proposed to four-track the present two-track South Boston Cut, which is the approach to the Boston Freight Terminal. Two additional tracks are to be constructed and eleven overhead bridges rebuilt so as to span four tracks instead of two.

Work not yet started.

**The Fore River Shipbuilding Co.**, Quincy, Mass., has the following work in progress:

Ten submarines for U. S. Navy.

One submarine for Royal Spanish Navy.

Two oil tankers for Texas Co.

One molasses tanker for Cuba Distilling Co.

One oil tanker for Argentine Republic.

Five cargo vessels for E. F. Luckenbach.

Two oil tankers for Pan-American Petroleum Co.



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BOSTON SOCIETY OF CIVIL ENGINEERS  
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PAPERS AND DISCUSSIONS

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THE COMMERCIAL FERTILIZER INDUSTRY IN THE  
UNITED STATES.

BY LESTER W. TUCKER,\* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

INTRODUCTION.

A PAPER by the writer on "The Phosphate Rock Industry of Florida" was read before the Society in June, 1914.† In the subsequent discussion the question was asked as to what was done with the rock after it was received at the fertilizer factory, and how it was used in the manufacture of commercial fertilizer. The reply was that it was too long a story to be answered in an informal way, and the writer, believing that the Society would be interested in this subject, has prepared this paper to give an idea of the extent of the industry of the manufacture of commercial fertilizer in the United States, and a brief description of the method by which the phosphate rock is changed from its natural state to that in which it appears when sold under its many and various names as commercial fertilizer.

GENERAL.

Reliable statistics regarding the fertilizer industry in the United States are very hard to obtain. The Census of 1910

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NOTE. This paper will not be presented at a meeting of the Society, but discussion is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before November 10, 1916, for publication in a subsequent number of the JOURNAL.

\* Managing Engineer, Westinghouse, Church, Kerr & Co., New York.

† JOURNAL BOSTON SOCIETY OF CIVIL ENGINEERS, Vol. I, p. 509.

places the fertilizer industry forty-eighth in rank in the value of products of manufacture, and gives the number of establishments engaged in the manufacture, the number of persons employed and the capital invested as follows:

|                                       |               |
|---------------------------------------|---------------|
| Number of establishments.....         | 550           |
| Total number of persons employed..... | 21 950        |
| Capital invested.....                 | \$121 537 451 |

The tonnage of fertilizer used in the various states is given in a report issued by the Department of Agriculture of the United States in 1898, and also in a special bulletin from the same source for a part of the states from 1906 to 1909 and for all of the states from 1910 to 1913 inclusive. The fact that the close of the fiscal year in various states is at different periods causes a wide variation of yearly results in trying to correlate these figures. However, the figures give a fairly good idea of the amount of fertilizer used in each of these various states for the years given.

The growth of the industry in value of product since 1860 is shown by the United States Census for 1910 to have been as follows:

| Year. | Value of Production. |
|-------|----------------------|
| 1860  | \$891 344            |
| 1870  | 5 815 118            |
| 1880  | 23 630 795           |
| 1890  | 39 180 844           |
| 1900  | 44 657 385           |
| 1905  | 56 541 253           |
| 1910  | 103 960 213          |

The increase in value of product from 1905 to 1910 is much greater in proportion than it has been for the previous years shown. This increase has been caused to a great extent not only by the greatly increased use of fertilizer for the cotton crops in the South and for many of the northern states, but also by increase in value of products. Fig. 1 shows that the increase in consumption from 1905 to 1911 is largely due to the increased use of fertilizer in the so-called cotton belt and adjoining states. It will be noted that the annual rate of increase has been nearly



the same in both the cotton belt states and the states north of them, if we neglect the abnormal increase of the years 1910 and 1911 in the cotton belt states. This annual increase appears



to be, under normal conditions, about 200 000 tons per year in both groups of states.

The number of plants engaged in the industry in the various states is very indefinite. The United States Census for 1910 gives the total number of plants as 550 for the entire United States, while the State of Georgia Year Book for 1913 gives a list of persons and factories engaged in the industry as 415 in that one state alone. Eliminating from this list the cotton seed oil plants and the persons who are simply acting as selling agents for certain mixtures, the total number of plants is reduced to about 135, which, if we take into account the factories recently built, agrees closely with the United States Census Reports for 1910. The figures in the year books of the various states include so many selling agents and cotton seed oil plants that they are not reliable indices of the actual number of manufacturing establishments. From a careful perusal of the number of establishments given in the 1910 Census, and from a personal knowledge of many of the factories in the eastern part of the United States, the writer believes that the figures given in the United States Census for 1910 are practically correct and has adopted them in this paper. This number for the last twenty years is as follows:

| Year. | Number of<br>Establishments. |
|-------|------------------------------|
| 1890  | 390                          |
| 1900  | 422                          |
| 1905  | 399                          |
| 1910  | 550                          |

Grouping the various states in order to study the growth of the industry since the first available statistics were taken in various sections of the United States shows that the greatest consumption has always been in the cotton states. The New England states show a substantial increase, especially in Maine, while the Central states show large gains in the last ten years. The states west of the Mississippi River show a very small consumption, it being very evident that the soil in that section has not yet been exhausted to the extent where commercial fertilizer is necessary. In Texas, one of the greatest cotton-

producing states in the South, there is a comparatively small use of fertilizer, which from the 1912 and 1913 reports would not seem to be increasing to any great extent. California shows a small increase, which it is expected will continue in the future, as the use of fertilizer in the fruit and vegetable crops is found beneficial.

The annual increase in the United States for the past six years has been an average of about 480 000 tons per year, the maximum increase being from 1909 to 1911, when the increase was 900 000 tons per year. The increase in the future, while subject to the same business conditions as all other industries, must, as a whole, continue to show a substantial growth if the agricultural interests are to be maintained at the same rate of progress in the future as in the past.

#### HISTORY.

The manufacture and use of what is officially known as commercial fertilizer in the United States dates back to about the year 1840, when a commodity known as Peruvian guano was brought into the United States from the islands off the west coast of South America. Some years later, in the early sixties, the manufacture of a fertilizer made from fish and sold under the name of fish guano was begun, and several other mixtures under various names were also put on the market about this time. The discovery of potash salts in Germany and the teachings of Dr. Von Leibig were followed by the discovery of phosphate rock in South Carolina in 1867. Acid phosphate was then first introduced as a part of these fertilizers, and it is with the manufacture of this kind of commercial fertilizer that this paper will deal directly.

The enormous use of commercial fertilizer in recent years has been possible only through the discovery of the phosphate rock in the United States and the potash salts of Germany, the supply of Peruvian and other guanos being practically exhausted, and the fish products are nearly all used in conjunction with the phosphate. It is the phosphate rock and potash which to-day makes the manufacture of commercial fertilizer an important industry.

## MANUFACTURE.

The manufacture of commercial fertilizer is practically the same wherever it is carried on. Factories are located all the way from Maine to the Gulf and from the Atlantic to west of the Mississippi River. Several cities have become important centers for the manufacture of fertilizer, being chosen by the various companies on account of their superior locations for receiving and forwarding material as well as for distribution centers.

As was described in a former paper, phosphate rock is shipped from the mines in as nearly a dry condition as is possible and is received at the various factories and kept in this same dry condition until it is ready for the grinding or pulverizing.

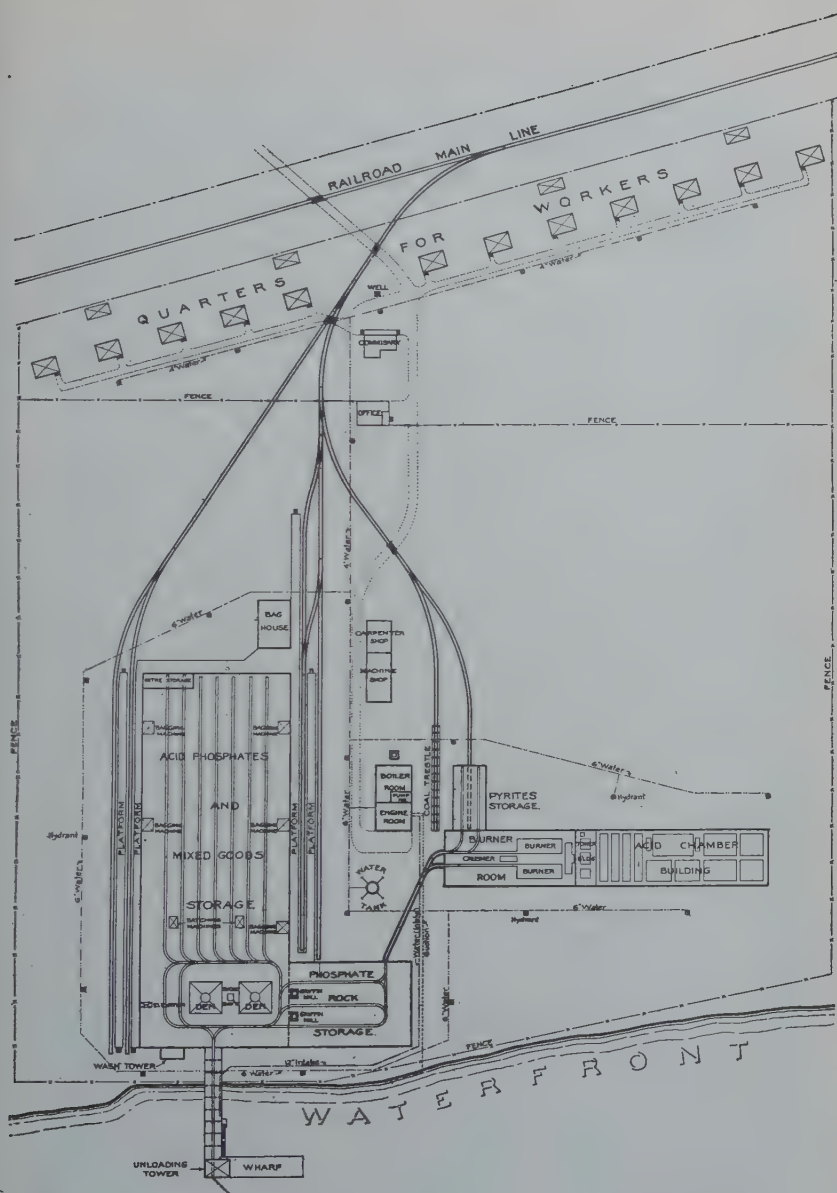
A complete fertilizer establishment consists, in a general way, of a factory building with its attendant storage sheds, acid plant, bag factory, power plant, office, shops and general quarters for the employees, together with facilities for receiving raw material and shipping out the finished goods. Many of the factories do not have an acid plant connected with them, buying their acid in bulk as needed.

A typical cross section for a factory is shown by Plate I to give an idea of how the rock is handled from the time it leaves the ship or car in which it is received from the mine until it is finally deposited in the shape of acid phosphate or base goods in the storage sheds.

A description of an acid plant is not necessarily a part of this paper, but it can be said that such a plant consists of a furnace room in which are located the furnaces for burning the sulphur or pyrites, the towers for denitration of the gases and acid, and chambers for the condensation of the gases to acid. Roughly speaking, a ton of acid is required for each ton of phosphate rock used. The acid most commonly used is sulphuric acid ( $H_2SO_4$ ) at a density of 50 degrees, Bo. scale.

The fertilizer factory consists, for the major part, of storage space. Most of the factories are obliged to furnish storage for the equivalent of nearly their entire year's output. For example, a factory may have an output of 60 000 tons, and storage space must be supplied for acid phosphate and base goods for





TYPICAL  
LAYOUT FOR FERTILIZER FACTORY.



SCALE OF FEET.

FIG. 2.

practically this total amount, as the shipping season for nearly all the factories lasts only about six weeks and there must be on hand, at the beginning of the shipping season, acid phosphate, base goods and mixed goods for practically the total output of the factory. A factory can be said roughly to consist of storage for phosphate rock, mixing floor and machinery, dens, conveyors, tankage, batching and bagging machines, and storage for acid phosphate, base and mixed goods. The typical cross section of a factory shows in a very general way how the materials are handled from the time they are received at the factory until they are shipped out in the finished state.

The phosphate rock, upon being received at the factory, is taken from the vessel or car and placed in the storage pile. The first process which it goes through is that of grinding or pulverizing, the rock being taken from the storage pile and put through a Griffin mill or some of the later types of mills used especially for phosphate rock, such as the Bradley, Raymond, Kent or Sturtevant mills, which pulverize it until it passes through the No. 100 mesh screen which is a part of the mill. From these mills the pulverized rock passes by means of screw conveyors and elevators to the storage bin over the mixing floor. Also over the mixing floor is located an acid tank for the storage of sulphuric acid. Immediately below the ground-rock bin is located a weigh hopper for weighing the rock used, and a small measuring tank for measuring the acid used. Immediately below the mixing floor, and on a level with it, is the mixer. Mixers are of various makes, but are similar in operation. They consist of round iron cylinders about 18 in. deep and 8 ft. in diameter in which are installed paddles or stirrers working in opposite directions. These mixing pans are located directly over large receptacles called dens into which the mixed materials are dumped. The method of operation is to dump into the pan the proper amount of ground rock from the weigh hopper, following it immediately with the proper amount of acid, which is carefully measured. The pan is then started and run the necessary length of time to mix the contents thoroughly, which are then dumped into the den. This procedure continues until the den is filled.

In the manufacture of base goods, the proper proportion of ammoniates is added to the contents of the mixing pan with the acid and phosphate rock so that the whole mass may become thoroughly mixed before going to the dens. The dens are made airtight, except for a flue leading to the wash tower in which is located a fan carrying off the fumes arising from the chemical changes which take place. These fumes are condensed in the wash tower by means of sprays in order to prevent the obnoxious odors from being generally spread through the atmosphere. Many of the factories have gone to a great deal of expense in building wash towers so that the fumes shall cause as little trouble as possible to the surrounding country, and there are many plants where, a few hundred feet away, it would scarcely be known that any such operation was being conducted.

It will be noticed that careful weighing and measuring of all stock used is one of the most noticeable things about one of these factories.

The mass remains in the den for about twelve hours, after which time it has become thoroughly cooked, and is then removed to piles in the storage buildings until it is ready to go to the batching machines. A batching machine consists of a boot for the deposit of the various ingredients which are to be batched, elevators, shaking screens, mixing machine and pulverizers. From the boot the ingredients are elevated and passed over screens to eliminate all hard lumps, the material which passes through the screens being passed through the mixing machine and then taken by an elevator and carried to a hopper on the top floor. The lumps or balls which are rejected by the screen are passed through a cage mill or pulverizer, where they are broken up and again passed through the boot and mixer before going again over the screens. In the batching machines the various potash, nitrate and other ingredients to make up the proper mix are added. The batched material is then stored until ready for bagging. It is then taken from the storage piles, passed through the bagging machines, which are somewhat like a batching machine, but without the mixer, where it is again pulverized, the lumps being taken out and only the fine material going into the bags. The bags are so arranged that they are

filled immediately from the spouts, automatically weighed, the bags sewed and placed in the car for shipment. In some factories the batching and bagging machines are combined, but the continuity of the operation is somewhat interfered with when this is done. A batching machine will batch from 40 to 50 tons per hour, while a bagging machine with two spouts usually bags from 20 to 25 tons per hour. In the shipping season these bagging machines are running practically twenty-four hours a day, for, as before stated, the entire tonnage of one of these factories has to be turned out in the very short shipping season which precedes the planting time in the various communities. Goods are seldom batched until they have been from seven to ten days out of the dens, as the tendency to lump is very much greater if batched sooner than this. Fertilizer will not set after being milled a second time, and it is for this reason that the batched goods are put through the pulverizer a second time.

#### COMMERCIAL GRADES.

There are so many different grades of commercial fertilizer on the market that it would be impossible to give any description of the various formulas by which they are manufactured. All of the fertilizers in which phosphate rock is used are based on three principal ingredients, — acid phosphate, ammoniates and potash, —and it is the number of parts of each one of these three ingredients which give to the fertilizers as sold their various names. In practically all the states of the Union it is now necessary to stamp on the bag the formula under which the fertilizer is manufactured. In several of the states each bag has to have a state tag attached, certifying as to the formula under which it is mixed, the number of pounds in the bag, and the exact parts of each ingredient going in to make the mix. In New Jersey, Georgia, South Carolina, Alabama and some other states, the sale of these tags by the state practically fixes the amount of fertilizer sold within the state. In other states the formula and weight must be printed in letters at least  $\frac{3}{4}$  in. high on the outside of the bag. In nearly all of the states the requirements are such that inspectors from the various agricultural bureaus have



the right to make an analysis of the contents of any single bag, and if it is found to be at variance with that shown on the tag or the printed formula on the bag, the manufacturer is subject to heavy fines. For interstate traffic the United States Department of Agriculture has various inspectors who go into any factory and take samples of the mixed goods for analysis to see that they are as stated in the formulas. In fact, it is safe to say that the contents of a bag of fertilizer are as near what the formula on the bag states as it is possible to make it, and this applies wherever it is sold in the United States.

For one who is not actively engaged in the manufacture of this product and who passes through a factory on a casual visit and sees the number of men rushing about with wheelbarrows, one with potash, one with nitrates, another with additional ammoniates, it is impossible to realize that at every machine where these various loads are dumped, everything has been carefully weighed and every particle of the ingredients going into a single batch will check out in the end with the formula which is printed on the bag. To get these various mixes right and to keep them right in their various handlings through the factory with the class of help which is here employed, would seem to be almost impossible, and that it is done and that the formulas are very seldom found to be wrong when the fertilizer is inspected shows the thoroughness of the organizations by which the various factories are managed.

An industry connected with all of the plants where any large amount of fertilizer is manufactured is the making and printing of the bags in which the finished product is shipped. The jute from which the bags are made comes in large rolls and the bags are cut, sewed and the name and formula printed on them in the bag factory. This part of the industry is hardly to be classed as coming under the general head of this paper, but it is an absolute necessity and of considerable importance, and at many plants which have been visited great care and ingenuity have been shown in the ways and means of making and printing these bags.

## POWER PLANTS.

The power plants connected with the various factories vary in size and equipment according to the necessities of the plant. As a general thing, it can be said that these are up to date and entirely adequate to the necessities. Of course many of the older plants have machinery which is rather out of date, but it is of such efficiency that will not warrant changing it. The power required varies so much at the different seasons in the year, being a maximum during the shipping season of only six or eight weeks and a minimum practically the rest of the time, that a plant is not justified in installing new equipment for this short season when the old will carry them through and is perfectly adequate for ten months in the year. All the modern plants are electrically driven, having individual motors for all machines, so that the use of power for all parts of the factory is limited to the requirements of each machine.

One of the necessary parts of the power equipment is the pumping plant, which has to be of a capacity sufficient not only to supply the wants of the factory, but also to keep the fire protection system under pressure at all times.

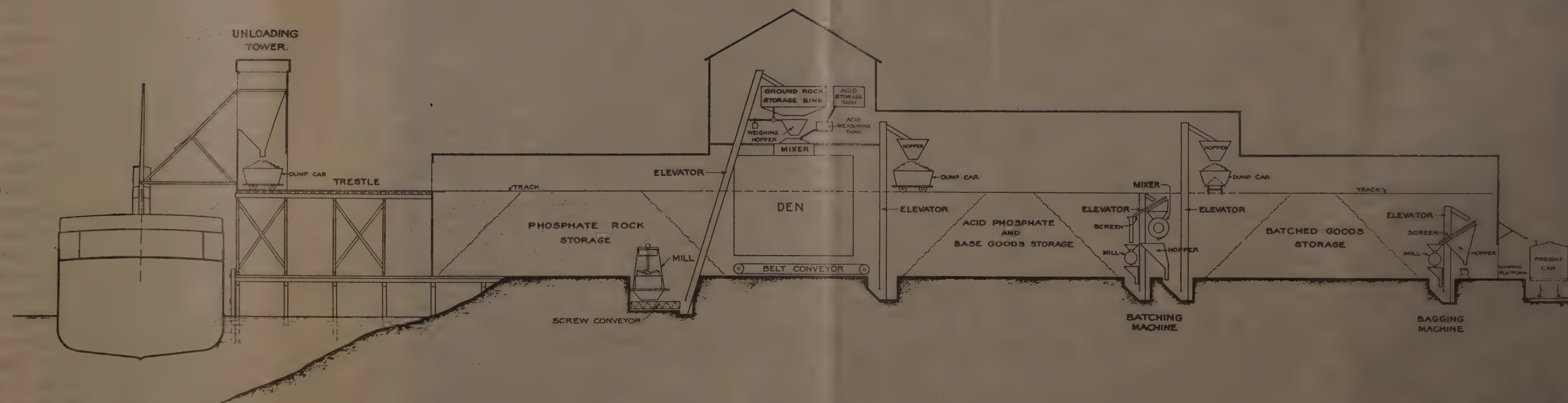
## LABORATORY.

At all of the plants where goods are manufactured, a laboratory is maintained and chemists are engaged the year around in testing the goods, checking formulas and in experimenting on changes in existing formulas. As practically all formulas used have to be registered in the various states where goods are sold, this department is one of the most important and one in which the greatest efficiency has to be maintained.

## LABOR AND EFFICIENCY IN MANUFACTURE.

The writer has visited nearly one hundred fertilizer plants located in all parts of the United States. In the factories of the northern states the lower classes of white labor are generally used, while in the southern states negro labor is employed exclusively. In the southern part of California, the Mexican peon is employed, while in the vicinity of San Francisco, Chinamen

# DIAGRAMATIC CROSS SECTION OF FERTILIZER FACTORY.







of the lower class are used. In all cases the labor may be said to be of about the lowest class, and when it is considered that with this class of labor, superintendents and foremen in these various factories ship thousands of tons of fertilizer, mixed in some cases to as many as forty different formulas from one factory, and that these mixtures are made with practically no mistakes, it must be noted that the efficiency of the foremen and superintendents is equal to or better than that of those employed in what are usually classed as high-grade factories.

It was observed in visiting many of these plants that the superintendents and higher class foremen were not only of the better grade of Americans, but were in many cases college-bred men, quick, sharp and aggressive, working during the rush season twelve or fifteen hours a day, and making good in an industry which would not seem to be as attractive as many others which they might have chosen, but which from its very exacting requirements keeps them in a high state of efficiency and up to a stiff standard of responsibility all the time.

The condition of both buildings and equipment of the plants which have been visited can be said to have been maintained equal to that which has prevailed in many other industries which the writer has visited in the last several years. The large number of new plants which have been started since 1910 is especially noteworthy, and while there has been a slight setback for the last year or so, due to delayed sales resulting from the present war and lack of potash from Germany, it can be said that few industries present a better outlook for future growth. In conclusion, it can be said that with the great increase in the use of commercial fertilizer in the United States which will be necessary to maintain the output of the soil and which will result from broader education in the use and economic value of fertilizer, the engineer, be he civil, mechanical, electrical or chemical, will be called upon more and more to work out the general ways and means and the detail of the various parts of this industry from the mining of the rock to the delivery of the finished product to the consumer.



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THE SEWAGE DISPOSAL PROBLEM CONFRONTING  
THE CITY OF PHILADELPHIA.

BY W. L. STEVENSON.\*

(Presented before the Sanitary Section, June 7, 1916.)

## ABSTRACT.

THE purpose of this paper is to show the present conditions at Philadelphia as related to sewers, water courses and water supply, and to describe the plan adopted for the collection, treatment and disposal of the sewage which provides for the division of the city into three main sewerage areas, furnished with high- and low-level intercepting sewers and disposal works with the degree of treatment deemed necessary for the sewage.

Of the three divisions, the Northeast is selected for description of proposed sewerage works, as it is nearest the source of the city's water supply, and, as funds are now available for the Frankford Creek high-level intercepting sewer, it is described in more detail to give the important features of the design of the entire plan.

## INTRODUCTION.

*Location of Philadelphia.*—The city of Philadelphia is situated on the west bank of the Delaware River about one

NOTE. Discussion of this paper is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before November 10, 1916, for publication in a subsequent number of the JOURNAL.

\* Assistant Engineer in Charge, Sewage Disposal Division, Philadelphia.

hundred miles from the Atlantic Ocean. The Schuylkill River and Frankford and Pennypack creeks flow through the city, and Poquessing and Cobbs creeks form its boundaries respectively on the northeastern and western sides.

The city embraces 130 square miles and now has a population of 1 700 000. The estimates indicate a population in 1950 of 3 000 000.

*Present Sewers.* — The present sewers are on the combined system, except on the watershed of the Schuylkill River above Fairmount Dam and its tributary, Wissahickon Creek, where the separate system has been installed, from which rain water is discharged directly to the watercourses and sewage conducted by an intercepting sewer, the outlet of which is in the Schuylkill River below Fairmount Dam.

An intercepting sewer has been built along Cobbs Creek to convey the dry-weather flow and first flush of rain water from tributary combined sewers to a point on the creek below the built-up part of the city.

Intercepting sewers, a pumping station and a treatment works for the populated part of the watershed of Pennypack Creek near its mouth were completed in 1912. These works of 2 000 000 gals. a day capacity consist of coarse screens, grit chambers, Emscher tanks, a percolating filter, disinfection apparatus and a final settlement basin. They produce a clarified, non-putrescent and nearly sterile effluent, protecting from local pollution the water of the Delaware River at the Torresdale intake, which is only 2 000 ft. above the mouth of Pennypack Creek.

As these works treat about  $1\frac{1}{4}$  million gallons of sewage out of the present estimated 400 million gallons a day produced by the city and discharged into the watercourses, the condition of these streams is of interest and has a direct bearing upon the order of procedure in constructing the proposed intercepting sewers.

*Condition of Streams.* — The entire watershed of Poquessing Creek and the watershed of the upper part of Pennypack Creek are sparsely settled, and these creeks are, therefore, normal, clean streams. The Wissahickon Creek and the Schuylkill



River above Fairmount Dam, being protected from sewage pollution from Philadelphia by intercepting sewers, are reasonably clean, although the Schuylkill River carries the sewage of a large population from its watershed above Philadelphia. Cobbs Creek is still considerably polluted by sewage from the adjoining county.

Frankford Creek, the Schuylkill River below Fairmount Dam, and the docks of the Delaware River are all seriously polluted both by the sewage discharged into them daily and by decomposing deposits of sewage origin on their beds, caused by insufficient velocity of flow to maintain the sewage solids in suspension.

The Delaware River has a normal flow of upland water of 4 050 sec.-ft. and an extreme dry weather flow of 2 030 sec.-ft. This represents, during normal conditions, 2.4 sec.-ft. upland water per 1 000 persons contributing sewage from Philadelphia alone. The river has a tidal range of  $5\frac{1}{2}$  ft., and 2 421 000 000 cu. ft. of water flow past the city in the  $7\frac{1}{2}$  hrs. during the ebb tide. The velocity of the water due to the tidal flow is sufficiently high to maintain the sewage matters in suspension, so that the entire bed of the Delaware River at Philadelphia is clean and free from sewage deposits, excepting in the docks.

In this river the city possesses a great natural sewage-oxidizing plant. As the water of the Delaware River reaches the northern or upstream limits of the city, its oxygen content in warm weather is about 80 to 95 per cent. of complete saturation. As it flows past the city and receives the sewage either directly from sewers or indirectly from Frankford Creek and the Schuylkill River, the oxygen content is decreased in summer to an average as low as 12 per cent. of complete saturation during July, August and September, with single samples entirely devoid of dissolved oxygen. Even at such times no offense from odors from the water has ever been noted, except in the docks.

For several miles below the mouth of the Schuylkill practically no sewage enters the river, and the absorbed oxygen and the natural biological agencies of the Delaware River cause a marked improvement in the condition of the water as it flows along toward Chester, ten miles below.

*Water Supply.* — One third of the water supply of the city is obtained from the Schuylkill River above Fairmount Dam and two thirds from the Delaware River at Torresdale near the northern limit of the city. The river water is purified by preliminary and slow sand filtration, and sterilization with liquid chlorine, so that a superior quality of water is delivered to the people.

The water intakes on the Schuylkill are protected from sewage pollution from Philadelphia by the separate system of sewers and intercepting sewer mentioned before. The Torresdale intake is unprotected save by the Pennypack Creek sewage treatment works. Fortunately, the population adjacent to this intake is scattered, and only a few sewers exist for several miles below the intake.

*The Problem of Sewage Disposal.* — The conditions being as described, it is evident that the problem of sewage disposal confronting the city of Philadelphia consists in:

Protection of the source of the water supply taken from the Delaware River at Torresdale;

Restoration of the streams which are now polluted by sewage to a clean condition, and their permanent maintenance in that condition, together with means for prevention of future sewage pollution of streams now clean;

Improvement of the port by cleansing the docks now sludged up and providing against future sewage pollution of them, and maintenance of the water of the Delaware River in a sufficiently clean condition that there will be no danger of nuisance even during extreme droughts in summer.

Because of the large area involved and the importance of obtaining practical results from funds as they may be appropriated in allotments of a few millions, the successful solution of the sewage disposal problem in Philadelphia is dependent mainly upon the system of intercepting sewers adopted.

For example, one of the plans investigated in the preliminary studies was the collection of all the sewage of the city to a point on the Delaware River below the mouth of the Schuylkill River and positively below any possible influence upon the Torresdale water intake, so as to reduce to a minimum the degree of treatment of the sewage.

This plan was rejected because no protection from nearby pollution was afforded the Torresdale intake until there would have been completed the intercepting sewer along the Delaware River from the mouth of the Schuylkill River.

The cost of this sewer, with its appurtenant siphon and pumping stations, would amount to \$22 000 000, which is only \$400 000 less than the estimated cost of the entire plan which was adopted.

### THE ADOPTED PLAN.

The comprehensive plan for the collection, treatment and disposal of the sewage of Philadelphia, recommended in the report published in 1915 and subsequently approved by the Pennsylvania State Department of Health, provides for the division of the city into three main sewerage areas, known as the Northeast, Southeast and Southwest divisions, each to be provided with a system of intercepting sewers to conduct the dry weather flow of sewage and first flush of rainfall to sites on the bank of the Delaware River.

*The Three Divisions.* — The Northeast division is that part of the city northeast of a line beginning on the Delaware River at Port Richmond and extending to and along the Wissahickon Creek. Its estimated population in 1950 is 1 100 000 and the treatment works will be designed for a daily flow of 208 000 000 gals.

The Southwest division is that part of the city included in the watersheds of the Schuylkill River, the southwest side of Wissahickon Creek, the northeast side of Cobbs Creek and that part of the Delaware River watershed having sewer outlets between Port Richmond and Market Street. The estimates indicate that in 1950 1 663 000 people will dwell in this division and will produce 417 000 000 gals. of sewage a day.

The Southeast division is that part of the Delaware River watershed south of Market Street and east of Broad Street. The estimates indicate that a population in 1950 of 390 000 in this division will produce 82 000 000 gals. of sewage a day. The Southeast division is quite flat and will be provided with only a single intercepting sewer approximately parallel with the Delaware River.

*High and Low Level Intercepting Sewers.* — Comparative estimates showed that in the case of the Northeast and Southwest divisions, which include high land, economy would be secured even by an increased cost of the construction of the sewers by building them at two levels to minimize the annual charges for pumping by delivering to the works by gravity the sewage from the high land.

This principle is shown in the design of the intercepting system for the Southwest division, in which a main gravity intercepting sewer extends about  $11\frac{1}{2}$  miles from the site of the Southwest works to a terminus northeast of the center of the city. Grades along the lower part as low as .02 ft. per 100 are made possible by adding to the sewage directly collected by gravity as much sewage as possible collected by low-level intercepting sewers and raised by pumping to the main gravity flow to increase its volume as much as possible.

*Degree of Treatment.* — The plan recommended in the report issued in 1915 involves the use of coarse screens and grit chambers for all three treatment works, to be followed by sedimentation and sludge digestion in Emscher tanks at the Northeast and Southwest works and by fine screening at the Southeast works, where, in comparison with the other two plants, a relatively small quantity of sewage will be received and which will be located in a part of the city expected to develop into a great industrial section where a more extensive treatment works is impractical.

The tanks at the Northeast works have been planned to be built at such an elevation that their effluent can be applied to percolating filters in the future when the protection to the source of the water supply will require more refined treatment than only the removal of the settleable solids.

It was recognized that processes of sewage treatment, especially oxidation, are being improved very rapidly, and it was thought that these improvements will surely allow of less loss in head and area than are required for percolating filters; therefore ample land and head are provided for the future.

In the case of the Southwest works, the effluent of which will have no effect upon the water supply of the city, estimates of



cost showed it to be economical to place the tanks at an elevation just high enough for a gravity discharge to the river, and if, in the future, more refined treatment should be required, it will then be necessary to pump the tank effluent to the required elevation.

*Disposal.* — At all three works the effluent will be discharged through submerged outlets in the channel of the Delaware River in such a way as to insure its mingling with the great tidal flow of the river and thus utilize to the highest possibility its great diluting and oxidizing power. Sludge can be used for filling low land adjacent to the Northeast and Southwest works, and screenings will be incinerated at the Southeast works.

This use of the Delaware River for the ultimate purification of the sewage is in recognition of the fact that modern life in large cities has placed so many demands upon available funds that natural resources must be utilized to the fullest extent compatible with good sanitation, and the cost for construction and operation of artificial sewage treatment works kept at a minimum.

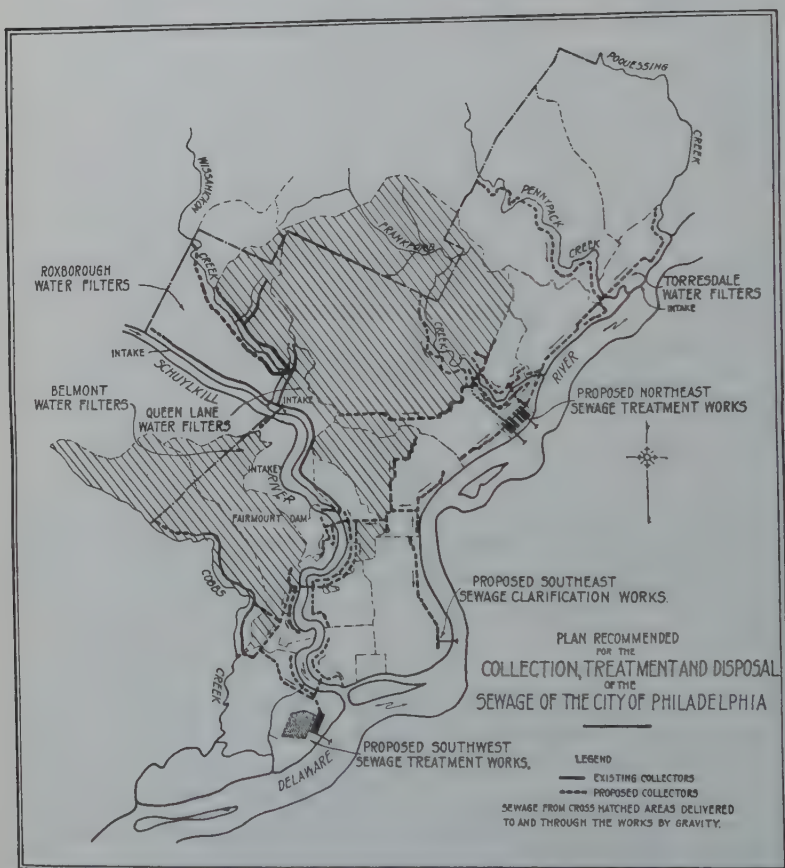
#### THE NORTHEAST DIVISION.

As the Northeast division of the city is nearest the source of water supply at Torresdale, the first funds appropriated for sewage disposal will naturally be expended there, and hence a brief description of the collecting system for this division is of interest.

*Separate System Sewers.* — On the drainage areas tributary to the Delaware River over four miles below Poquessing Creek, the separate system of sewers will be installed and also connections made from the storm water sewers to the intercepting sewers to collect the first flush of rain water. This will protect the river for two miles above and two miles below the intake of the Torresdale water filters from the discharge of any sewage from Philadelphia even during rainstorms.

The entire watershed of Pennypack Creek will be furnished with the separate system of sewers, as both banks of this creek will be a park and the creek enters the Delaware River 2 000 ft. below the Torresdale water intake. In addition, those portions

of drainage areas between the intercepting sewers and the bank of the Delaware River will be supplied with separate sewage sewers laid to drain from the river toward the intercepting sewers, while the rain water will be carried in the storm water outlets of the combined sewers draining this part of the division.



*Combined Sewers.* — The remainder of this division will be sewered on the combined system, which is already installed over a large part of it, and the dry-weather flow and first flush of rainfall will be admitted to the intercepting sewers.

*The Intercepting Sewers.* — From the site of the Northeast works an intercepting sewer will be constructed approximately parallel to the Delaware River terminating at Poquessing Creek, which is the present northern boundary of the city. Into it will drain by gravity the low-level intercepting sewers to be constructed along the banks of the Frankford Creek and an intercepting sewer collecting sewage from the drainage area of Pennypack Creek.

The present Pennypack Creek works will be abandoned and the sewage now treated there will be pumped into the upper Delaware intercepting sewer and conveyed to the Northeast works.

Another low-level intercepting sewer will extend southerly from the Northeast works for about  $1\frac{1}{2}$  miles and carry upstream to the works sewage tributary to the Delaware River below the high-level intercepting sewer, which will be about 2 miles back from the river.

The sewage collected by these systems of low-level sewers will amount to 85 000 000 gals. a day in 1950, and will have to be pumped to pass through the treatment works.

Sewage from the western part of the Northeast division will be collected by two high-level intercepting sewers, one to be constructed across the city in an easterly direction to collect sewage normally flowing south and convey it to a point about two miles northwest of the site of the Northeast treatment works, the other to extend practically along the bank of Frankford Creek from county line to the terminus of the other high-level intercepting sewer. In 1950 these two sewers will deliver 120 000 000 gals. of sewage a day to a grit chamber, from which the sewage will be carried down a ridge street to the site of the Northeast works in conduits designed to act as an inverted siphon 7 000 ft. long. To meet the varying quantities as the general sewer system is extended and to maintain self-cleansing velocities and obtain the flattest possible hydraulic grade line to reduce losses in head, the complete installation will consist of 66-in., 78-in. and 90-in. tubes. These will deliver the high-level sewage to elevation —15 at the works. But if the blow-off gates at the lower end are open, the two smaller tubes will carry all the high-level

sewage with the hydraulic grade line lying within the tubes to elevation  $-6.5$ , which is sufficiently high to provide fall through a works consisting only of tankage.

#### THE FRANKFORD CREEK HIGH-LEVEL INTERCEPTING SEWER.

Subsequent to the issuance of the Report on Sewage Disposal, Councils of Philadelphia appropriated \$500 000 and authorized the construction of the Frankford Creek high-level intercepting sewer from the Delaware River nearly to the county line. This work is partly designed in detail, and about a mile of sewer is now under contract.

A description of the important features of this sewer and its appurtenances will indicate most of the principles upon which the project for the entire city is based.

*Determining Sizes of Intercepting Sewers.*—To determine sizes of the intercepting sewers and treatment works for the whole city, the first requirements were estimates of the quantities of sewage to be collected both at present and in 1950. Gagings were, therefore, made of the dry-weather flow in several sewers draining characteristic areas, and, from studies of distribution and growth of population, estimates were made of the population contributing to the gaged sewers and also of the 1910 and 1950 estimates of population on each existing and proposed drainage area in the city above the point where the intercepting sewer would collect the sewage.

From these data, average flows per capita for different kinds of areas were determined and applied to the ungaged sewer areas.

From a study of these gagings it was also determined that in the larger sewers the daily maximum rate of flow would be 128 per cent. of the average.

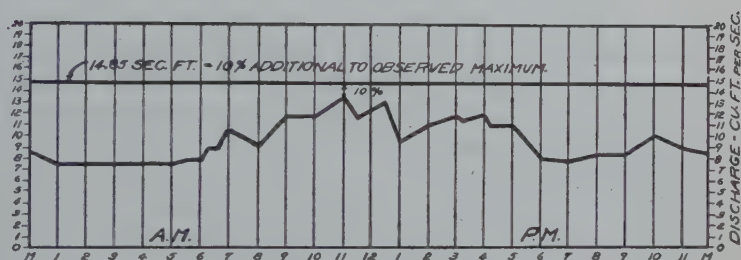
It was decided to admit to the intercepting sewers the first flush of rain water to a minimum amount equal to 10 per cent. of the daily maximum rate of dry-weather flow. This makes what will be called "storm maximum flow" equal to 141 per cent. of the average dry-weather flow.

In consideration of the fact that storms are as likely to occur

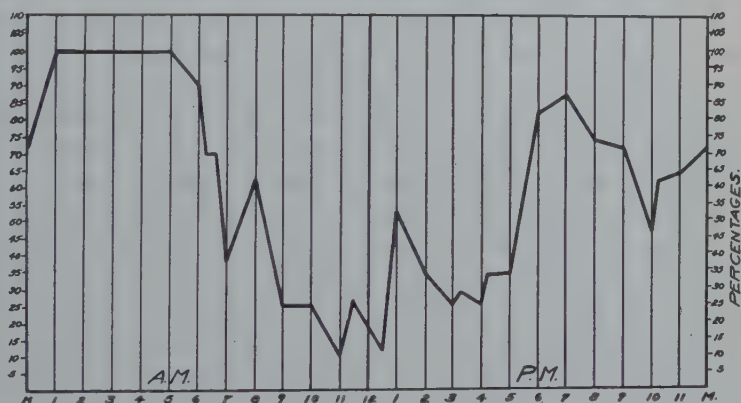


at times of daily minimum flow as at the maximum, an examination of certain gagings showed that on an average this decision

DIAGRAM SHOWING GAUGED DRY WEATHER FLOW OF THOMAS RUN SEWER.



PERCENTAGE THAT ADMITTED RAIN WATER IS OF DRY WEATHER FLOW OF SEWAGE.



SEWAGE DISPOSAL DIVISION,

BUREAU OF SURVEYS.

MAY, 1916.

meant that an amount of rain water equal to 55 per cent. of the dry-weather flow will be admitted to the intercepting sewers. A study of certain drainage areas indicates that this amount of

rain water represents storms of an intensity of .013 in. per hour.

The records of the United States Weather Bureau showed that in Philadelphia about 700 rainy hours can be expected a year, and of these, during 350 hours, storms of .01 in. per hour or less may be anticipated. In other words, the decision to admit 10 per cent. rain water in addition to the maximum dry-weather flow provides on the average for no overflow of sewage to the streams during about one half the rainy hours of the year.

The intercepting sewers were designed to carry the "storm maximum flow," or 141 per cent. of the 1950 estimated average flow, at three-fourths capacity, which in circular sewers is at two-thirds depth.

The hydraulic grade line of the estimated 1950 storm maximum flow was used in designing these sewers, which were then examined for self-cleaning velocities using the invert grade and the 1910 daily minimum flow.

*The Upper Part of the Sewer.* — The Frankford Creek high-level intercepting sewer begins at the county line as a 3-ft. sewer, which is large enough to receive the sewage of 55 000 persons from the adjoining county if the boundaries of the city are extended in the future. It will be constructed along the bank of Tacony Creek through park property for a distance of about three miles to the mouth of Wingohocking Creek, where it will be 5 ft. in diameter. The capacity of this sewer provides for the admission of 200 per cent. of the 1950 average flows in order to afford more adequate protection to the creek through the park.

The Wingohocking Creek at this point now carries the drainage of Germantown (a section of Philadelphia), discharged into it from a 19.5-ft. combined sewer which will be extended to the mouth of the creek in the future.

It is planned to construct the invert of the outlet portion of the future combined sewer, deflect the creek into it, and divert the dry-weather flow into the intercepting sewer, allowing the storm flows to pass to the creek.

This will be one of the largest sewers in Philadelphia to be connected to an intercepting sewer, but the principles involved

in the construction are common to nearly all the points of interception.

*Method of Interception.*—It is common practice to place intercepting sewers entirely beneath combined sewers and to admit the sewage to the intercepting sewer either through a slot or by a weir or through a gate controlled by a float which is actuated by the height of water either in the combined sewer or in the intercepting sewer.

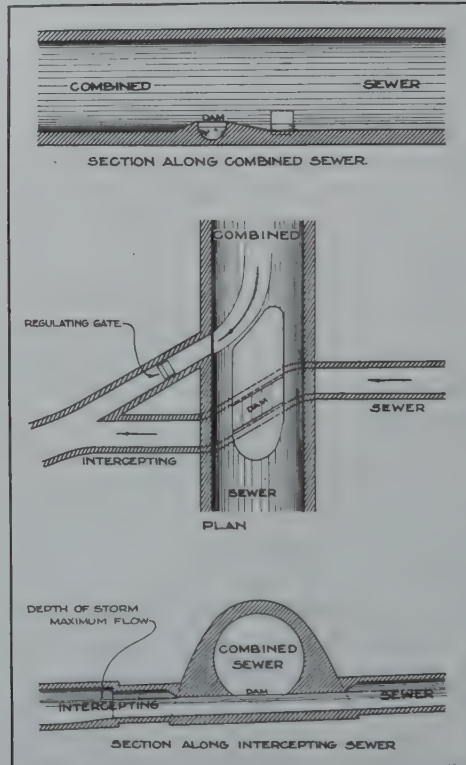
In such construction there is a considerable loss in head, and when only a slot is used, there is no control of the amount of rain water admitted to the intercepting sewer when storm water fills the combined sewer. The complicated mechanism of the float-controlled valves is also a cause of trouble, and requires considerable expenditure for maintenance.

To overcome these difficulties, a new design has been made, consisting of a combination of the intercepting device used in Dresden, Germany, and a regulating gate without any float control designed by one of the engineers of the Bureau of Surveys in Philadelphia.

The maximum hydraulic grade line in the intercepting sewer is fixed at the point of interception at or as near below as possible to the 1950 estimated "storm maximum" elevation of water surface in the combined sewer. This means that generally the intercepting sewer passes through the combined sewer. It will be recalled that the intercepting sewers are designed so that "storm maximum flows" are at three-fourths capacity or in circular sections at two-thirds depth. The one-third air space in the intercepting sewer is discontinued as the intercepting sewer is carried through the combined sewer, and the top of the intercepting sewer is constructed of cast-iron plates which form the crest of a dam in the invert of the combined sewer. It will be noted that the crest of this dam is at the elevation of "storm maximum" flow in the combined sewer, and hence serves to hold back all flows of less than that amount.

In the side of the combined sewer and upstream from the dam a rectangular opening is made to carry the dry-weather sewage flow and such portion of storm water as predetermined to the intercepting sewer.

In this rectangular conduit, between the combined sewer and the intercepting sewer, there is placed the regulating device, which consists of a structural steel rectangular leaf, supported below its center by a horizontal shaft. The natural tendency of

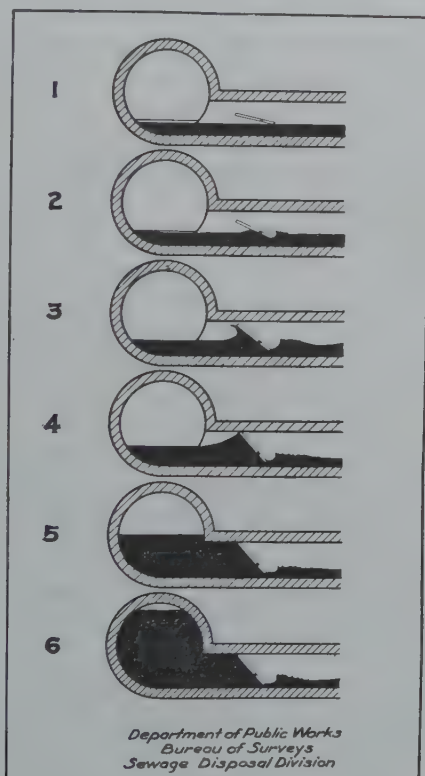


the leaf is to rest against stops in a nearly horizontal position, due to the fact that the center of gravity of the leaf is above the point of support.

The horizontal shaft is placed at about the same elevation as the crest of the dam in the combined sewer, and consequently all flows below this elevation pass freely under the regulator into the intercepting sewer. When storm water increases the depth



of flow to an elevation above the horizontal shaft, the lower part of the leaf offers resistance to the free flow and causes the water to rise in back of the gate, which increases the pressure upon the upper part and causes the gate to begin to close. The rate of



closure depends upon the velocity of approach to the gate and to the height of water beyond the gate.

In its closed position the upper part of the gate bears against the top of the rectangular conduit, but the lower part of the gate is designed to clear the bottom of the conduit by an amount sufficient to leave an opening beneath, so that when the combined sewer runs full, the head upon the opening will cause a discharge

under the regulator equal to the average dry-weather flow. This allows a velocity in front of the gate to keep grit in the storm water moving forward, instead of settling in the approach to the gate.

When the flow in the combined sewer abates to an elevation where the hydrostatic pressure on the upper part of the gate is less than upon the lower part, the natural tendency of the regulator causes it to open and the normal flows are resumed to the intercepting sewer.

*The Lower Part of the Sewer.* — To resume the description of the Frankford Creek high-level intercepting sewer, after the dry-weather flow has been diverted into the sewer by the device described above, it will be conveyed for nearly a mile through an 8.5-ft. semi-elliptical concrete sewer (now under contract) along the most direct route, which requires three tunnels to the point where the central Delaware high-level intercepting sewer mentioned before will join it. Here an entire block of ground about 580 ft. square, upon which to erect a grit chamber, has been condemned.

It will be recalled that the Frankford Creek intercepting sewer above this point is designed to carry a storm maximum flow of 200 per cent. of the average flow, whereas the treatment works will have a normal maximum capacity of only 141 per cent. of the average. The reduction in quantity will be effected just before the sewage enters the grit chamber by constructing an overflow chamber, one side of which will consist of a dam whose elevation will be placed at the proper elevation to allow 141 per cent. of the average flow to pass on, while the excess flows on to a sewer discharging into Frankford Creek at a point below the Park.

The grit chamber will be provided at its entrance with a set of bulb bars spaced about 10 or 12 ins. apart to restrain large objects which should not, but may, gain entrance to the intercepting sewer. It will be designed with a capacity of 170 000 000 gals. a day, which is its 1950 estimated storm maximum rate. It will consist of three cells, each about 100 ft. long, 18 ft. wide and, at maximum flow, 6 ft. deep. The cross section is a rectangle with the two lower corners cut off at 45 degrees, so that, as

the depth of flow varies, the cross section in service will maintain velocities of about one foot per second. In order to do this, devices will be required at the outlet end of each cell to maintain the water surface at desired elevations. Studies have been made of a series of vanes having elongated, lozenged-shaped cross section and fastened to vertical shafts, which will be held in a frame sliding in grooves in the side of the effluent channels. When the shafts are set so that the longer edges of the vanes are parallel to each other, they will offer but little resistance to the flow of sewage. By the turn of a handle at the top, however, the vanes can be placed so as to offer any amount of resistance up to complete closure.

It is planned that the grit chambers will be constantly in service, which requires grit removal without unwatering a cell. Several devices have been studied, such as conveyors and water ejectors, and while, as yet, no definite decision has been made, it is most likely that a simple grab bucket operated from a crane will be used.

Contrary to the usually accepted idea, the deposit in this grit chamber is not expected to be clean sand and, as there is every indication that the neighborhood will be developed into a residential section, it is of the utmost importance to prevent any offense from bad odors. It is, therefore, planned to wash the deposit in a manner similar to that used in the Torresdale water filters and to provide storage bins from which the clean sand can be removed for use on the sludge drying beds at the Northeast works.

In connection with this grit chamber, several studies have been made of screens as a protection to the long inverted siphon between it and the works. In order to avoid the necessity of hauling away or incinerating the screenings, serious consideration is being given to installing inclined bar-screens with clear openings of about 2 ins. or  $2\frac{1}{2}$  ins., the screenings to be passed through crusher rolls to reduce them in size to less than the openings in the screens and then to discharge them into the grit chamber in front of the screens.

The effluent of the grit chamber will be carried for about 1200 ft. to a valve chamber through a conduit, the invert of

which will not be parallel to the arch. The arch will be made parallel to the 1950 storm maximum hydraulic grade line, and the invert grade will be made sufficient to cause self-cleansing velocities with the minimum flows from Wingohocking Creek when the sewer is first placed in service.

At the lower end of this sewer the storm maximum hydraulic grade line approaches the street surface, and, as has been stated before, in order to conserve the potential energy in the sewage from the high land, the principle of the inverted syphon will be utilized for about 7 000 ft. to the site of the Northeast works.

The head of the pressure tubes will consist of an underground chamber containing three sluice gates controlling entry to the 66-in., 78-in. and 90-in. tubes. At first only the 66-in. tube will be built, as it has ample capacity as a sewer to carry to the Delaware River the sewage to be intercepted by the present construction. The lower end of the siphon tubes will be provided, when it is desired to discharge sewage to the high tank elevations, with turn-up tubes and blow-off gates to induce scouring velocities.

#### FUTURE APPROPRIATIONS.

On May 16 last, two loan bills to provide \$115 000 000 for municipal improvements were favorably voted upon by the citizens of Philadelphia. This sum includes \$3 200 000 for sewage disposal, toward acquisition of land, for the construction of the intercepting sewers and the treatment works for the Frankford Creek drainage area.

Philadelphia looks forward to the actual realization of this plan, which has been under investigation and study since 1907, and the hope is that the results accomplished by the expenditure of these funds will demonstrate the advisability of carrying out the entire scheme which is a solution of the sewage disposal problem now confronting the city of Philadelphia.



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BOSTON SOCIETY OF CIVIL ENGINEERS  
FOUNDED 1848

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## PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

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### A METHOD OF TRANSFORMING LATITUDE AND LONGITUDE INTO PLANE CO-ORDINATES.

By STURGIS H. THORNDIKE,\* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

THIS article will scarcely be of general use or interest to engineers. Occasionally, however, any engineer may find it highly important to obtain the location in plane coördinates of a group of points whose latitude and longitude he knows. The following simple and accurate method of transformation may then be the means of saving gray-matter, time and money for him, as it has been in the experience of the writer.

Many engineers, who are constantly using plane coördinates, hesitate a little to utilize in connection with them determinations by latitude and longitude. They associate latitude and longitude with spherical excess, the  $LMZ$  formula, and other complications, and hardly care to take the time to study up processes which they have not used since they left college, and to make sure that they still understand them.

There is a certain sound basis for this hesitation, since it is a fundamental impossibility to represent a spherical surface accurately on a plane surface; the best possible method gives merely an approximation, and the inaccuracies become greater

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NOTE. This paper will not be presented at a meeting of the Society, but discussion is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before November 10, 1916, for publication in a subsequent number of the JOURNAL.

Of Fay, Spofford & Thorndike, Consulting Engineers, Boston.

and greater as the distance from the center of the system is increased. However, within a circular area of 12 miles radius, the spherical surface of the earth can be represented on a plane with an error of less than 0.15 ft. at the circumference, and at a 24-mile radius this error still does not reach 1.25 ft.

Whatever method of transformation is used, the origin should preferably be chosen near the center of the area involved; if it is located at one corner, or outside the area, this unavoidable "spherical" error will be unnecessarily large at the diagonally

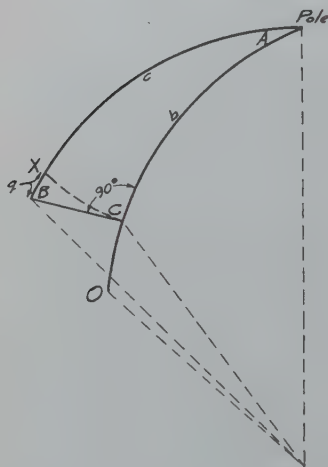


FIG. 1.  
(Spherical Surface.)

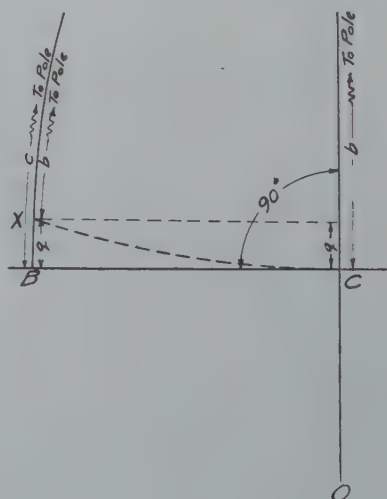


FIG. 2.  
(Plane Surface.)

opposite corner and may become troublesome. But the plane coördinates can still be kept all of the "plus" sign by giving to the coördinates of the origin a large numerical value. In Boston, the State House is taken as the origin, and all coördinates are calculated from its meridian as an axis; but the coördinates of the State House are frequently assumed as 50 000 ft. N. and 50 000 W., so that there are no "minus" values within the city limits.

The method described below requires no understanding of spherical trigonometry except the simplest application of the spherical right triangle. Although it involves approximations, the effect of these is hardly noticeable as distinct from the inevitable "spherical" error alluded to in the preceding paragraphs. In Massachusetts, the method gives, at a distance of four or five miles from the meridian of the origin, a determination of position differing by less than 0.1 ft. from that given by the usual but cumbersome "*LMZ* method" (inverse solution).

*Required*, the plane coördinates of the point *X* whose latitude and longitude are known.

In Figs. 1 and 2, let *O* be the origin of the system of plane coördinates, the latitude and longitude of *O* being known.

Let *CO* be a portion of the meridian through *O*; i. e., the north-and-south or vertical axis of the coördinate system.

Let *XC* be a portion of the parallel of latitude passing through the point *X*; the distance from *X* to the pole, or from *C* to the pole, is the co-latitude of the point.

At *C*, erect a perpendicular to the vertical axis; on a sphere this is a portion of a great circle, from which the parallel *XC* will diverge by an amount *q* at the point *X*.

Using approximations, which can be shown to be quite negligible, the plane coördinates of *X* are at once seen to be (Fig. 2):

(1) Westing = *CB*; this is the difference in longitude, *A*, between the meridian of the origin and the meridian through *X*, reduced from angular measurement (in seconds) to linear measurement.

(2) Northing = *OC* + *q*; this is the difference in latitude between the point and the origin, corrected by the divergence *q* and reduced from angular measurement (in seconds) to linear measurement. If *C* lies south of *O*, *q* must be subtracted from *OC*.

It is convenient to keep the discussion and calculations in angular measurement, seconds, making the final transformation into linear measurement the last step of all.

The distances *OC* and *CB* are already known in angular units. The determination of the only remaining distance, *q* = *BX*, is very simple, and is as follows:

In Fig. 1 is shown the right spherical triangle having the angle of 90° at the point *C*.

*b* is the co-latitude of the point *X*.

*c* is equal to *b* plus the divergence *q*.

*Required*, the value of *q*.

$\cos A = \frac{\tan b}{\tan c}$  (spherical right triangle; the only spherical formula required).

$$\frac{\tan c}{\tan b} = \frac{1}{\cos A}.$$

$$\log \tan c - \log \tan b = \text{colog } \cos A.$$

Since  $c$  differs from  $b$  by  $q$  seconds,  $\log \tan c$  will differ from  $\log \tan b$  by  $q$  times the tabular difference for one second in the table of logarithmic tangents at angle  $b$ . That is,  $\log \tan c - \log \tan b = q \times \text{tab diff}$ .

$$\text{Then, also, } \text{colog } \cos A = q \times \text{tab diff, and finally } q = \frac{\text{colog } \cos A}{\text{tab diff}}.$$

That is, to find any value of  $q$  in seconds, it is merely necessary to *divide the colog cos A by the proper tabular difference*.

Where a number of neighboring points are to be transformed from spherical into plane coördinates, the most convenient process is to select a central latitude and there plot a curve showing corresponding values of, (1) difference in longitude,  $A$ , and, (2) divergence,  $q$ ; Fig. 3 is such a plot, values of  $q$  being calculated and plotted at intervals of 30 sec. in value of  $A$ . The divergences have such small values and the tabular difference changes so slightly within the few minutes of latitude usually covered that this one curve may generally be utilized throughout the system, and from it the value of  $q$  for any required point can readily be read.

In Table 1, the second column shows the value of the colog cosines for angle  $A$  each 30 sec. from  $0^\circ$  to  $0^\circ 15'$ . These same values are used at whatever latitude a curve is to be plotted, and it may be convenient to have them at hand instead of hunting up a logarithmic table carried to the ten places desirable to give accuracy.

The third column of Table 1 shows divergences at latitude  $42^\circ 6'$ , the center of Springfield, Mass. In this case, each colog cos was divided by .0000042327, the tabular difference in logarithmic tangents at  $47^\circ 54'$  (the co-latitude).

Fig. 3, a plot of these divergences, is really the parallel  $42^\circ 6'$  plotted on a plane to a much-distorted scale. In practice, it might be well to make this diagram on a larger scale than shown.



In transforming the distance  $CB$  from seconds into linear units, the linear equivalent of a second of longitude at the

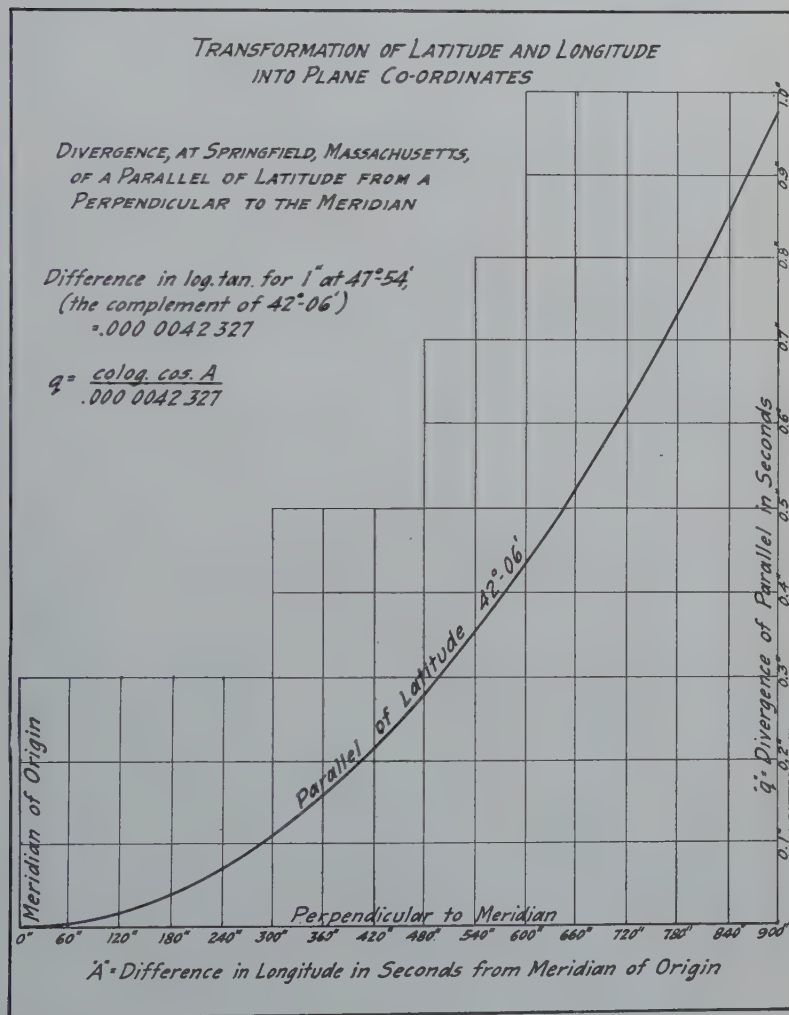


FIG. 3.

latitude of  $X$  should be used. In transforming the distance  $OC + q$  from seconds into linear units, the linear equivalent of a

second of latitude at the mean latitude of  $X$  and  $O$  should be used. The most convenient place to obtain these equivalents is from the constants  $A$  and  $B$  of the  $L M Z$  formula as published by the United States Coast and Geodetic Survey in the Superintendent's reports for 1894 and 1901, and in "Special Publication No. 8," published in 1911. These constants are also given in "Geographic Tables and Formulas," compiled in 1904 by Samuel C. Gannett, of the United States Geological Survey.

$$1'' \text{ longitude} = \frac{1}{A} \cos \text{lat.}$$

$$1'' \text{ latitude} = \frac{1}{B}.$$

The linear equivalents of angles of latitude and of longitude are also tabulated in "Tables for a Polyconic Projection of Maps," third edition, Special Publications No. 5, 1910, Department of Commerce and Labor, United States Coast and Geodetic Survey. In these tables, however, the equivalents are not carried to enough significant figures to give the accuracy usually required in coördinate calculations.

This article and the equivalents referred to in the preceding paragraph furnish all that is necessary to utilize latitude and longitude determinations in any system of plane coördinates. To utilize to the full the refinement given by the values of  $\log \cos A$  in column 2, Table 1, the tabular difference for  $1'$  in  $\log \cotan$  at the central latitude might be carried to ten places instead of the usual seven places, but this will seldom be necessary.

The latitude and longitude of a point are seldom determined to greater refinement than .001 sec., roughly,  $1\frac{1}{16}$  ft. As it is of no avail to carry the refinement in the reduction formula further than the accuracy of the original data, the method just described has, therefore, a precision greater than can usually be utilized.

#### SUMMARY.

The easting (or westing) of a point is the difference in longitude from the meridian of the origin, reduced to linear measure at the latitude of the point.

The northing (or southing) of a point is its difference in

latitude from the origin, corrected by the divergence of its parallel of latitude from a perpendicular to the meridian of the origin, and reduced to linear measure at the mean latitude of point and origin.

TABLE I.

DIVERGENCES AT SPRINGFIELD, MASS., OF A PARALLEL OF LATITUDE FROM A PERPENDICULAR TO THE MERIDIAN.

The tabular difference for one second in the table of logarithmic tangents is .0000042327 at the tangent of  $47^{\circ} 54'$ , the co-latitude of the center of Springfield.

Divergences are stated in seconds of latitude.

| Angle $A$<br>= Diff.<br>in Long. | Colog Cos $A$ . | Divergence $q$<br>= $\frac{\text{Colog Cos } A}{.00000042327}$ |
|----------------------------------|-----------------|----------------------------------------------------------------|
| $0^{\circ} 00' 30''$             | .000 0000 046   | 00.00109"                                                      |
| 01 00                            | 00 184          | .00435                                                         |
| 01 30                            | 00 414          | .00978                                                         |
| 02 00                            | 00 735          | .01736                                                         |
| 02 30                            | 01 149          | .02715                                                         |
| 03 00                            | 01 654          | .03908                                                         |
| 03 30                            | 02 251          | .05318                                                         |
| 04 00                            | 02 940          | .06946                                                         |
| 04 30                            | 03 721          | .08791                                                         |
| 05 00                            | 04 594          | .10854                                                         |
| 05 30                            | 05 559          | .13133                                                         |
| 06 00                            | 06 615          | .15628                                                         |
| 06 30                            | 07 764          | .18343                                                         |
| 07 00                            | 09 004          | .21272                                                         |
| 07 30                            | 10 336          | .24419                                                         |
| 08 00                            | 11 760          | .27784                                                         |
| 08 30                            | 13 275          | .31363                                                         |
| 09 00                            | 14 883          | .35162                                                         |
| 09 30                            | 16 583          | .39178                                                         |
| 10 00                            | 18 374          | .43409                                                         |
| 10 30                            | 20 258          | .47860                                                         |
| 11 00                            | 22 233          | .52527                                                         |
| 11 30                            | 24 300          | .57410                                                         |
| 12 00                            | 26 459          | .62511                                                         |
| 12 30                            | 28 710          | .67829                                                         |
| 13 00                            | 31 053          | .73364                                                         |
| 13 30                            | 33 488          | .79117                                                         |
| 14 00                            | 36 014          | .85085                                                         |
| 14 30                            | 38 633          | .91272                                                         |
| 15 00                            | 41 342          | .97672                                                         |

## DISCUSSION.

GEORGE L. HOSMER.\* — The method of calculating plane coördinates described by Mr. Thorndike was devised by him in 1898 and employed to calculate, from the known latitudes and longitudes, the coördinates of the corners in the boundary lines and harbor lines surrounding the city of Boston. When comparing the results obtained by this method with those found by the so-called *L M Z* formulas it was noticed that there was a very small but apparently systematic difference between the two. Mr. Thorndike's results invariably placed the triangulation points a few hundredths of a foot south of the positions assigned by the *L M Z* formula. Recently, in connection with the calculation of plane coördinates in the city of Springfield by the two methods, the question again arose as to the cause of the discrepancy. The following discussion is the result of a study to ascertain the true relation of the two formulas.

Before investigating the errors of the formulas themselves it is desirable to determine the errors arising from the assumption that a spherical surface may be represented on a plane.

## ERRORS OF A PLANE-COÖRDINATE SYSTEM.

In order to investigate the error involved in surveying on the surface of a sphere of the size of the earth and then computing the results on the assumption that the surface is a plane, let us suppose that the plane on which the computations are to be made is tangent to the sphere at a point *O*, and that a point *A* on the surface of the sphere is defined as lying N 45° W from *O* and at a distance of 20 000 meters (about 12 miles) measured on a great circle. Denote this path from *O* to *A* as "Route 1." By solving the spherical right triangle, using a radius corresponding to the mean curvature in latitude 42°, we find that if a traverse be run due north 14 142.159 m. and then, turning 90°, run westerly 14 142.124 m. on a great circle, without any errors in the measurements, this traverse will terminate exactly at point *A* on the spherical surface (Route 2). If, now, the coördi-

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\* Member Boston Society of Civil Engineers.



nates of  $A'$  on the plane be computed by the routes mentioned, we find for these coördinates —

|                 | $x$           | $y$           |
|-----------------|---------------|---------------|
| Route 1.....    | 14 142.136 m. | 14 142.136 m. |
| Route 2.....    | 14 142.124    | 14 142.159    |
| Difference..... | -.012         | +.023         |

This shows that in passing from  $O$  to  $A$  by Route 2 we place point  $A'$  about .02 m. north and about .01 m. east of the position

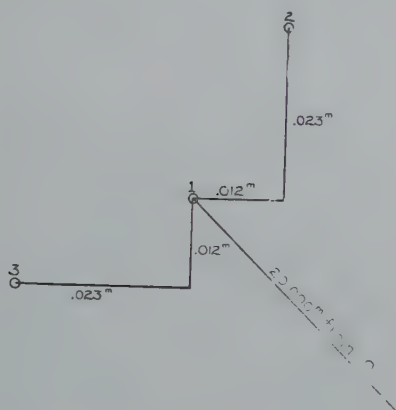


FIG. 4.

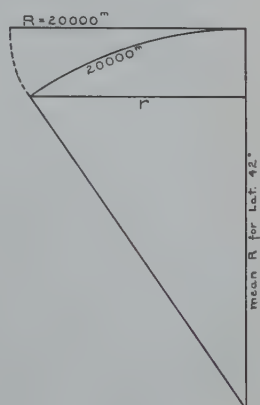


FIG. 5.

found by Route 1. A similar traverse (Route 3) running westerly on a great circle perpendicular to the meridian of  $O$ , and then turning  $90^\circ$  and running northerly to  $A$  would place  $A'$  .02 m. west and .01 m. south of that found by Route 1. The relative positions of these three points are shown to scale in Fig. 4.

The extreme divergence of positions 2 and 3 is about .05 m., or about 2 in. This represents the error of closure which would be found in a traverse run from  $O$  by Route 2 to  $A$  and back by Route 3 to  $O$ , but computed as a plane traverse. It should be observed that the measurements themselves are supposed to be

exact and that the closure of the field-work on the spherical surface is supposed to be perfect.

It is interesting in this connection to note that the length of the circumference of a circle having a radius  $R=20\,000$  m. exceeds the length of the circumference of a circle whose radius ( $r$ ) is the sine corresponding to an arc of  $20\,000$  m. by about  $0.21$  m. (Fig. 5). This is about four times the error shown in Fig. 4. This  $0.21$  m. represents, therefore, the total amount of stretching that would occur at the outer edges of the spherical segment if this portion of the sphere were forced to lie flat on the plane. It is also the discrepancy that would be found if a traverse were run around the circumference of our 12-mile circle, and its length compared with the length of the circumference as computed from its radius.

It should be observed that these errors are due entirely to the nature of the problem and have nothing to do with errors of measurement. It is obvious, however, that these errors are very small when compared with the errors of measurement of even very high-grade field-work. In deciding whether any formula is an appropriate one for making these calculations, our judgment will naturally be influenced by the fact that these spherical errors are bound to enter the results, as well as by the simplicity of the formula itself and by a consideration of the magnitude of the errors which are admissible in good field-work.

#### METHODS OF CALCULATING PLANE COÖRDINATES.

In calculating plane coördinates from the given spherical coördinates, we have a choice of these three methods. First, we may use, in its customary form, the "inverse" solution of the  $L M Z$  formulas, the two points being the origin and the triangular point whose plane coördinates are desired. Second, we may modify this solution, as was done in the city of Springfield, as follows: The  $x$  coördinate is found by converting into feet the difference in longitude between the origin and the given point; the  $y$  coördinate is found by converting into feet the difference in latitude, taking factor  $B$  for the middle latitude, and then increasing or decreasing this distance by the amount in feet of the offset from the great circle to the parallel as found

by the expression  $\frac{\tan \phi}{2N} \cdot x^2$ , which is obtained directly from the *L M Z* formula for difference in latitude when the azimuth is taken as  $90^\circ$ ; for convenience we shall refer to these as the "Springfield formulas." Third, we may use the method described by Mr. Thorndike.

#### ERROR IN THE ASSUMPTION THAT $x$ EQUALS THE DIFFERENCE IN LONGITUDE IN LINEAR UNITS.

A computation of the difference in length of the  $x$  coördinate and the actual arc of the parallel for the case already dis-

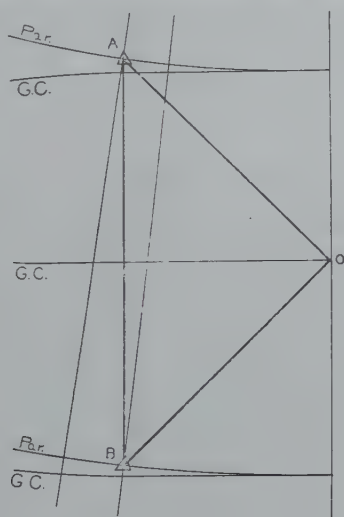


FIG. 6.

cussed (latitude  $42^\circ$ ) shows it to be but  $.002+$  m., which is insignificant in comparison with the inevitable spherical errors already mentioned.

#### ERROR IN $y$ OF THE SPRINGFIELD FORMULA.

(A) *When Corrections are made at the Parallel of A.*

In order to compare these methods let us suppose that a second point *B* (Fig. 6) is located S  $45^\circ$  W from *O* at a distance

of 20 000 m. If we calculate the geodetic coördinates of *A* and *B* by the *L M Z* formulas and then calculate the length of *AB* by an inverse solution, we obtain 28 284.25 m. This agrees with the actual meridian arc in meters, after allowing for the inclination of *AB* to the meridian of *A*. This length is .02 m. shorter than the plane distance (28 284.27), as it should be according to Fig. 4.

If we calculate the coördinates of *A* and *B* by applying the correction  $\frac{\tan \phi}{2N} \cdot x^2$  at the parallels of *A* and *B*, and then compute the distance *AB*, we obtain 28 284.33 m. This result exceeds the plane distance by .06 m., owing largely to the fact that we have assumed that the two great circles through *A* and *B*, perpendicular to the meridian of *O*, are parallel to each other, whereas they really converge about .05 m. (Fig. 6).

*(B) When Corrections are made at the Parallel of O.*

If we apply this correction as found for the latitude of *O*, we obtain for *AB* the distance 28 284.20 m. This is too short by .05 m. because no allowance has been made for the inclination of *AB* to the meridian of *A* (Fig. 6).

The true value lies between these two results. If the correction were calculated for the middle latitude of *OA* (and of *OB*), the resulting length would check the plane distance closely and would be much nearer the true distance than either of the others. In the *L M Z* formulas these errors are taken care of by the addition of the "*E*" term.

ERROR IN  $\gamma$  OF THORNDIKE'S FORMULA.

The length of *AB* as found by Thorndike's formula, for the latitudes of *A* and *B*, is 28 284.32 m., which checks (within .01 m.) that found by the Springfield formulas applied to the parallels of *A* and *B*. Although the length of *AB* checks the Springfield results, the  $\gamma$  coördinates themselves for *A* and *B* place each point about .06 m. south of the position given by the Springfield formulas, as shown in the table below.



|                                 | y Coördinates of A. |           | y Coördinates of B. |           |
|---------------------------------|---------------------|-----------|---------------------|-----------|
| Plane.....                      | N                   | 14 142.14 | (parallel of B) S   | 14 142.14 |
| Springfield, parallel of A..... | N                   | 14 142.16 | S                   | 14 142.17 |
| Springfield, parallel of O..... | N                   | 14 142.10 | S                   | 14 142.10 |
| Thorndike.....                  | N                   | 14 142.10 | S                   | 14 142.22 |

In order to compare Thorndike's formula with the  $L M Z$  formula, we may expand the numerator,  $\log \sec \text{diff. long. } (\Delta\lambda)$ , in series, from which we obtain

$$\begin{aligned}\log \sec \Delta\lambda &= \log \left[ 1 + \left( \frac{\Delta\lambda^2}{2} + \frac{5}{24} \Delta\lambda^4 \right) + \dots \right] \\ &= \log_{10} e \left[ \left( \frac{\Delta\lambda^2}{2} + \frac{5}{24} \Delta\lambda^4 \right) - \frac{1}{2} \frac{\Delta\lambda^2}{4} + \dots \right] \\ &= \log_{10} e \left[ \frac{\Delta\lambda^2}{2} + \frac{\Delta\lambda^4}{12} + \dots \right]\end{aligned}$$

Differentiating  $\log \tan b$ , or  $\log \cot \phi$ , to obtain an expression equivalent to "tab. diff. for one second," the denominator of his formula, there results

$$\begin{aligned}\frac{d (\log \cot \phi)}{d\phi} &= \log_{10} e \frac{\csc^2 \phi}{\cot \phi} \cdot \sin 1'', \\ &= \frac{\log_{10} e \cdot \sin 1''}{\sin \phi \cos \phi},\end{aligned}$$

in which  $\phi$  is the latitude and  $d\phi$  is in seconds. The second term in the expression for  $\log \sec \Delta\lambda$  is found to be negligible, hence

$$q = \frac{\left( \frac{\Delta\lambda^2}{2} + \dots \right)}{\sin 1''} \cdot \sin \phi \cos \phi;$$

and since, from the  $L M Z$  formula,

$$s \sin a = x = \Delta\lambda \cos \phi N \sin 1'',$$

therefore,  $q = \frac{\tan \phi}{2N^2 \sin 1''} x^2,$

$$= \frac{\tan \phi}{2NR \sin 1''} x^2 \left( \frac{R}{N} \right),$$

$$= Cx^2 \left( \frac{R}{N} \right), \text{ which is the "C" term of the}$$

*L M Z* formula, except that it contains the factor  $\frac{R}{N}$ . In this form it is evident that the only difference between Thorndike's formula and the *C* term of the *L M Z* formula is that the latter has been multiplied by  $\frac{N}{R}$ , where *N* is the normal and *R* is the radius of curvature of the meridian. This ratio is introduced into the *L M Z* formula for the difference in latitude in order to reduce the difference in latitude on the sphere of radius *N* to that corresponding to the actual curvature of the meridian at the given point.

#### CONCLUSION.

It thus appears that the sole error of Thorndike's formula is due to employing too long a radius of curvature of the meridian when calculating the offset from the great circle to the parallel. This might have been inferred *a priori*, since his formula for the *offset* is derived from a spherical triangle, and, in order to preserve its simplicity, no change is made in this part of his formula to allow for the spheroidal form of the earth.

On account of its greater simplicity, Thorndike's formula commends itself to any one not perfectly familiar with the *L M Z* calculations. The error involved in its use is not much greater than the error which, from the very nature of the problem, is sure to enter the result, no matter what formula is used in calculating the coördinates. Neither is its error any greater than that of the Springfield formulas, unless special precaution is taken to allow for this latter error. Finally, its error is quite small when compared with the errors to be expected in the field-work. From these considerations it is clear that the formula is sufficiently accurate for the purpose for which it is intended.

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BOSTON SOCIETY OF CIVIL ENGINEERS  
FOUNDED 1848

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## PAPERS AND DISCUSSIONS

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### DISCUSSION OF "PAN-AMERICAN USE OF THE METRIC SYSTEM."

BY MESSRS. FREDERICK BROOKS, ROBERT SPURR WESTON,  
ALFRED W. PARKER AND EDWARD P. ADAMS.

MR. BROOKS.\* — *Commercial Use of the Metric System is wanted, irrespective of Its Technical Applications* — To open the discussion, a few branches of business will be successively taken up, showing that, in commercial transactions, the buying and selling of goods, ancient, customary units of weight and measure have continued in general use, so that practically all our people have failed to enjoy the advantages of the metric system in domestic trade, whereas in a wide range of technical and scientific work the metric system is established, so that the skilled few in factories and laboratories are partially obtaining benefit from its convenience.

Electrical work is based upon the centimeter, the gram and the second, the so-called C.G.S. system, which was adopted for it half a century ago by the Committee on Units of the British Association for the Advancement of Science. As it is within this last half century that pretty much the whole development of electrical business has taken place, the metric system is securely fixed throughout its present enormous extension in the work of technical character; nevertheless, in the purchase of supplies and the market transactions with the non-professional public, old usage with pounds, feet, etc., remains to be eliminated,

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\* 31 Milk Street, Boston.

with the minor exception that the kilowatt is commercially used. That is used for electric lighting in the kilowatt-hours of the bills rendered to consumers; and it has partially supplanted the anomalous old horse-power, particularly in connection with hydro-electric development. Legislative action has been taken to sanction the electrical units based on the metric system, Congress having enacted in 1894 that they should be the units of electrical measure in the United States, and having more recently made a law about wireless telegraphy.

Chemistry, technically pursued, has been metric for fifty years. No one looks for ancient units in a chemist's laboratory; but, in the business of chemical processes on a large scale and of the manufacture and sale of chemical products, there is great use of them, and as yet the substitution of the kilogram, liter, etc., has to be regarded as exceptional, — such as the cases of the Solvay Process Company, Syracuse, N. Y.; the Merrimac Chemical Company, North Woburn, Mass.; the Pennsylvania Salt Manufacturing Company; E. R. Squibb & Sons, Brooklyn, N. Y.; and the Bausch & Lomb Optical Company, Rochester, N. Y., who put out a price-list headed "Prices of Chemicals are by Metric, NOT Avoirdupois Weight." It would appear to be easy in such business to complete the substitution if the persons with whom the chemists had to deal would accept metric measurement.

Pharmacy affords a plain illustration. Chemistry and the metric system of course are thoroughly taught in colleges of pharmacy, and apothecaries have for many years put up metric prescriptions. Metric measure has been fully introduced in the "Dispensatory," the reference manual of the physician, and in the "Pharmacopœia," the reference manual of the apothecary. In the medical work of the U. S. Marine Hospital Service, the Army and the Navy, the use of the metric system was long ago required by successive executive orders without any special enactment by Congress. I am very glad that these specially trained persons have advantage from the system; but that does not affect most of us, who, when we have a prescription filled, do not concern ourselves about its composition and are conscious neither of profiting if it is in metric measure nor of suffering if it



is in old scruples, minims or fluid ounces, of the magnitudes of which we are oblivious. Suppose, on the other hand, that in the apothecary-shop we purchase some gumdrops or other goods that are weighed out to us over the counter; neither the metric weight nor the ancient apothecaries' weight is used; this little transaction is commercial, and uses weight which we know as customary and which is called "avoirdupois." It is this avoirdupois weighing that it is important to have superseded by metric weighing, so that the great mass of our citizens, in the dealings with which they are concerned, may benefit by the change.

Similarly, the metric system is in use for making dietaries; but for the marketing of food supplies by provision dealers practical steps remain to be taken such as are now being urged in the National Wholesale Grocers' Association. According to an editorial article in the *Boston Transcript* of June 21, 1916, —

"In pursuance of a report submitted by a special committee to the convention in Boston, every wholesale grocer is urged to print on the labels of all canned and boxed goods not only the weight in English pounds and ounces, but also the metric equivalent. This custom will have two values. It will help to educate the American people in the metric system, and it will begin at once to reap the benefits for American goods abroad, especially in the South American countries, which a general adoption of the metric system promises. Furthermore, the grocers are preparing for their membership complete and easily used tables of equivalents, and are doing their utmost to show how the first year or two of the change might be rendered less difficult by their use."

It appears that the committee has also proposed to have an organization to educate the public as to the advantages of the metric system.

Among the non-commercial applications of metric measure sports have drawn wide attention to it, especially the Olympic Games and international contests in great variety. The weight and strength of athletes and students in colleges also have been largely compared and measured by metric units. Works of art in museums have been catalogued with dimensions in the metric system. Such things help a little toward getting metric units into men's minds, which is the essential point of its adop-

tion; but these matters are not commercial transactions such as everybody has to engage in. Quite apart from buying and selling, also, the metric system has been adopted in the work of some committees of the American Society of Civil Engineers. This appears in the report of the Committee on Uniform Tests of Cement, on pages 72-83, under Society Affairs, in the *Proceedings* for February, 1909, Vol. XXXV, No. 2; on page 79 is the paragraph, —

“51. — The metric system is recommended because of the convenient relation of the gramme and the cubic centimeter.”

Also the Committee to Codify Present Practice on the Bearing Value of Soils for Foundations, etc., used millimeters for dimensions in its report, on page 346, under Papers and Discussions in the *Proceedings* for March, 1916, Vol. XLII, No. 3; and, with regard to its sub-committee “A,” —

“It was agreed that, in all the work of this sub-committee, the metric system would be used, etc.” (Page 419, under Society Affairs, in the *Proceedings* for August, 1915, Vol. XLI, No. 6.)

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In manufactures and machinery, one of the first applications of the metric system in this country was nearly fifty years ago, at Waltham, Mass., to watches and tools for making watches (including metric screws), where it has been entirely successful. The same distinction as before may be made. When a man buys a watch he wants to know the time, not what machinery was used in manufacturing. That it has long been metric machinery does not directly benefit him even if he knows the fact; and if any or all manufacturers were still using old measure it would not directly injure him, who thinks nothing about it. Suppose, on the other hand, that the man is selling his watch-case as old gold for the melting pot, to be paid for by weight; in that commercial transaction it is to be desired that the weighing should be by the gram, the unit of the universal decimal system, rather than by any irregular old unit, and particularly by the incongruous, antiquated, if not forgotten, unit for which the abbreviation was “dwt.” This could be done simply by the substi-

tution in balances or scales of metric weights for old weights; nevertheless such commercial substitution has yet to be made generally, although in the technical work of mechanical and manufacturing establishments, as to which there has been a great outcry that change would be impracticable, the change has actually been made in many kinds of work, as in the case of watch manufacture. This is a humorous feature of the situation.

The Lafayette Worsted Company, of Woonsocket, R. I., made this statement about fourteen years ago, —

“A large proportion of our employees being from Europe, we use a good deal of the metric system for the inside wants of the mill, but we have to use the American measures and weights for the outside relations.”

This was printed under the heading, “The Textile Industry and the Metric System,” in the *Textile World* for November, 1902, among the replies to a questionnaire of prominent manufacturers representing the cotton and woolen industries throughout the United States. Another of the replies from the Massachusetts Mills in Georgia, Lindale, Ga., H. P. Meikleham, agent, contained the following sentence referring to the metric system:

“You are doubtless aware that a good many shops use this system.”

So long ago as 1898, the last report which the Committee on Weights and Measures made to the Boston Society of Civil Engineers contained the following paragraphs (*Journal of the Association of Engineering Societies* for April, 1898, Vol. XX, Proceedings, p. 49):

“Your committee have ascertained that quite a number of manufacturing concerns in this country are using the metric system in their work in part or whole, particularly those concerns which do an export trade. A partial list showing some of the kinds of business using this system is as follows:

“Manufacture of watches and watch tools, injectors, machine tools, measuring instruments, steam engines, ordnance, refrigerating machinery, chemicals and iron works.”

Important additions might now be made, including automobiles and their accessories and aeroplanes. An enormous increase in

the manufacture of munitions for war has taken place, the metric system being used. As an instructive example, a short quotation may be made from the progress report of the American Society of Civil Engineers' Committee on the Status of the Metric System in the United States, printed among Society Affairs in the *Proceedings* for October, 1908, Vol. XXXIV, No. 8 (see p. 427):

" . . . Your committee would cite the case of twenty locomotives built by the Baldwin Locomotive Works, in 1907, using the metric system exclusively, as described in the *New York Herald*, Sunday, June 16, 1907. Mr. Samuel Vauclain, vice-president of these works, in reply to an inquiry from your committee, states that there was no greater difficulty in working to the metric system than to the English system. In fact, it was found somewhat easier, and the workmen were less likely to make mistakes. Mr. Vauclain further states that they could change to the metric system or use both systems without incurring any appreciable expense at the time, and adds his opinion that, were we all using the metric system, it would be much more convenient to the workmen, and our errors would be appreciably lessened."

For us all to be using the metric system where we all have to act together, that is, in commercial transactions, it is not an indispensable condition (though it is a desideratum) that it should be in use in manufacturing processes at the same time, if some manufacturer for any reason, or for no reason, prefers at present to forego the advantages of having it inside his works for his own workmen. For us all to be using the metric system means that we must pay for our transportation by the kilometer and reckon freight by the kilogram or metric ton, in doing which we are not thinking of how the locomotive is built.

In England also it has been recognized that it is outside of the works that it is required to extend the use of the metric system. In a pamphlet which the Decimal Association issued some ten years ago, containing favorable opinions of Lord Kelvin and nearly a hundred other persons, there was on page 6 the following passage contributed by Lord Belhaven and Stenton, who has subsequently become president of the association:

"The opponents to this proposal appear to base their principal objections on the cost that it would involve to manu-



facturers to alter their plant and scales so as to work to centimeters instead of inches, etc. This, however, is not a necessary consequence. All that is proposed is that, in *trading*, goods should be sold by metric weights and measures. There is no difficulty in describing textile goods from existing looms and patterns in lengths of meters and breadths of so many centimeters. Similarly, machinery made on the present system can, if necessary, be described in metric terms."

On November 17, 1913, at a meeting of the Bradford Textile Society, the metric system was discussed, and the following remark was made by Mr. G. E. M. Johnson, the secretary of the Decimal Association:

"We do not propose to interfere with the interior arrangements of any factories or to inquire what standards are used there at all, so long as when the products are sold they are invoiced and described in the terms of the metric weights and measures."

To illustrate this simple matter of describing commercial quantities and dimensions in metric terms, a quotation may be made from what had been said just previously in the principal address of the meeting by Alexander Siemens, past-president of the Institution of Civil Engineers. Here it is:

"When before a parliamentary committee I was asked: 'Seeing that in the cotton trade the standard make is what is called 79 ins.,  $37\frac{1}{2}$  yds.,  $8\frac{1}{4}$  lbs. shirting, — which is known the world over, — wouldn't it in some way damage the reputation of the shirting if the figures had to be recalculated in all the markets of the world?' Well, at the time I had not sufficient time in which to make the calculation. What do you get when you recalculate? Seventy-nine ins. are 2 meters within one third of one per cent.; 37.5 yds. are equal to 34 meters to within one third of one per cent.; and  $8\frac{1}{4}$  lbs. are  $3\frac{3}{4}$  kilograms. So you see you have been entertaining angels unawares. You have been manufacturing to metrical measure."

Likewise, in the subsequent discussion, Mr. Siemens referred to the point again saying, —

"... This change would not affect the processes of manufacturing in any shape or form. You would manufacture exactly as you have done before, only you would call the prod-

ucts by metrical names instead of by British names. As I showed you, 79 ins. by  $37\frac{1}{2}$  yds. by  $8\frac{1}{4}$  lbs. would be called 2 meters by 34 meters by  $3\frac{3}{4}$  kilos, but the cloth would be manufactured in exactly the same way."

An actual instance of description in metric denominations for commercial purposes was spoken of by Mr. John Pilter, who appeared in the name of the British Chamber of Commerce in Paris before the House of Commons Committee on Weights and Measures in 1895; the Blue Book gives his answer No. 2098 thus:

"With regard to the sizes of pipes which a member of this Committee mentioned, we have those same pipes sold in France with the French measures, and we experience no difficulty whatsoever. Instead of it being a three-inch pipe it is a pipe of a certain dimension in French. That is all. We, ourselves, do a large trade in iron pipes. The interior and exterior diameters are given in millimeters. It is a very easy thing to understand."

The American Society of Civil Engineers committee report quoted above contains a paragraph which summarizes this matter (p. 425):

"Throughout the commercial world the great majority of manufactured articles would remain absolutely unaffected by a change in units of measurement, because commercial sizes are nearly always nominal, and a suitable metric dimension can always be found which will satisfy all requirements."

What it will suffice to get done about this at first is to get commercial sizes expressed in metric terms. The committee report illustrated the matter by an extended table giving the actual diameters of pipes with the old designations commercially used for them in one column and corresponding designations in round numbers of millimeters in another column; and the report went on to say, —

"The even nominal metric sizes are in nearly every case nearer the actual sizes than are the nominal inch sizes in the first column.

"In like manner, tables of round, square and other steel shapes can be expressed in whole millimeters with sufficient accuracy to come within the actual variations of trade sizes, so

# APPROXIMATE EQUIVALENTS.

| LENGTH.                                |           |                                               | AREA.                        |           | BULK.                                          |                                |  |
|----------------------------------------|-----------|-----------------------------------------------|------------------------------|-----------|------------------------------------------------|--------------------------------|--|
| I in. and                              | (2.54)    | I sq. in. and                                 | 6 $\frac{1}{4}$ sq. centim's | (6.452)   | I cu. in. and                                  | 15 $\frac{3}{4}$ cu. centim's  |  |
| I ft. "                                | (30.48)   | I sq. ft. "                                   | 0.09 of sq. meter            | (.0929)   | I cu. ft. "                                    | 0.027 of cu. meter             |  |
| I Yd. "                                | (.9144)   | I sq. yd. "                                   | 0.81 " "                     | (.8361)   | I cu. yd. "                                    | 0.729 " "                      |  |
| I rod. "                               | (5.029)   | I sq. rod "                                   | 25. sq. meters .             | (25.29)   | 100 cu. ft. "                                  | 2.7 cu. meters                 |  |
| I ch'n "                               | (20.117)  | I rood "                                      | 1 000. " "                   | (1 011.7) | (The unit of ship's measurement for register.) |                                |  |
| I furl'g "                             | (201.17)  | I acre "                                      | 0.4 of hektar .              | (.4047)   | I M board meas. and                            | 2 $\frac{1}{4}$ cu. meters .   |  |
| I mi. "                                | (1 609.3) | I sq. mi. "                                   | 256. hektars . .             | (259.)    | I cord "                                       | 3.6 " "                        |  |
| WEIGHT.                                |           |                                               |                              |           |                                                |                                |  |
| I lb.                                  |           | and 0.45 of kilo                              |                              | (.4536)   | I U. S. liq. pint                              | 0.45 of liter . .              |  |
| 60 lbs. (wheat bu.)                    |           | " 27. kilos .                                 |                              | (27.216)  | I " " Qt.                                      | 0.9 " Liter . .                |  |
| 80 lbs. (coal bu.)                     |           | " 36. " "                                     |                              | (36.287)  | I " " gal.                                     | 3.6 liters . .                 |  |
| (.0648) I cental                       |           | " 45. " "                                     |                              | (45.36)   | I peck                                         | 9. " (U. S. 8.81; Br. 9.09)    |  |
| (31.103) 112 lbs. (cwt.)               |           | " 50. " "                                     |                              | (50.8)    | I bu.                                          | 36. " (U. S. 35.24; Br. 36.37) |  |
| I Net Ton                              |           | 0.9 Met. Ton                                  |                              | (.9072)   | I ton of ship's displacement                   | 1. cu. meter                   |  |
| (28.35) I gross ton                    |           | " 1. " "                                      |                              | (1.016)   |                                                |                                |  |
| COMBINATIONS.                          |           |                                               |                              |           |                                                |                                |  |
| I horse-power                          | and       | $\frac{3}{8}$ of kilowatt                     | . . . . .                    | (.746)    | POWER.                                         |                                |  |
| I foot-ton (net)                       | "         | 0.27 of (metric) ton-meter . . . .            | (.2765)                      | {         | WEIGHT AND LENGTH.                             |                                |  |
| I foot-pound                           | "         | 0.13 $\frac{3}{8}$ of kilogrammeter . . . . . | (.1383)                      |           |                                                |                                |  |
| I pound per running yard               | "         | $\frac{1}{2}$ kilo per running meter . . . .  | (.4961)                      | {         | WEIGHT PER LENGTH.                             |                                |  |
| I " " " foot                           | "         | 1 $\frac{1}{2}$ kilos " "                     | (1.4882)                     |           |                                                |                                |  |
| I pound per sq. foot                   | "         | 5. kilos per sq. meter . . . . .              | (4.882)                      | {         | WEIGHT PER AREA.                               |                                |  |
| (About 1 atmosphere) { 1 net ton " " " | "         | 1. kilo per sq. centimeter . . . .            | (0.9765)                     |           |                                                |                                |  |
| 15 pounds " " inch                     | "         | 1. " " " "                                    | (1.0546)                     |           |                                                |                                |  |
| I " " " "                              | "         | 0.07 " " " "                                  | (.0703)                      |           |                                                |                                |  |
| I net ton " " "                        | "         | 0.14 metric ton per sq. centimeter            | (.1406)                      |           |                                                |                                |  |
| I pound per cu. foot                   | "         | 16. kilos per cu. meter . . . . .             | (16.02)                      |           | WEIGHT PER BULK.                               |                                |  |

that with an allowable variation of 3 per cent. in sections, a change to the metric system would be a change in name only " (p. 425).

Going a step further, with only one decimal of the millimeter, metric value for all the customary subdivision of inches can readily be substituted. The inch is truly 25.4 millimeters; call is 25.6 millimeters and  $\frac{1}{16}$  inch becomes 1.6 millimeters, and 0.1 millimeter is thus the substitute for  $\frac{1}{25.6}$  of an inch; and every expression by the usual bisection of inches down to 256ths is simply provided for. This is easy compared with finding the equivalents in decimals of a foot, as we have been doing; and is not so far from correct as calling 2 ins. 0.17 of a foot and 4 ins. 0.33 of a foot. Its error is less than one per cent., being only half as great as in the familiar substitution of 25 millimeters for an inch; and it is close enough for the many occasions in which exact equivalence is not needed.

Another illustration of trade requiring metric denominations, regardless of what measure is used in manufacturing goods, was mentioned incidentally in the case of engines built by Williams & Robinson, at Thames Ditton in England. They had indeed introduced the metric system with complete satisfaction to their workmen and other parties concerned, as testified by\* Capt. H. R. Sankey, one of the directors of the company, in 1895, before the House of Commons Committee on Weights and Measures; but among his answers to questions he made a statement about their continuing also to make engines in the old style and dealing in them abroad where commercial measure was metric, saying (per page 73 of Blue Book, question 1241):

" . . . We sold some engines in Holland, and our Dutch agent — and I believe Holland is one of the places where English machinery is most welcome — wrote bitter letters to us saying that he could not get any orders until all the dimensions were translated into millimeters. I do not mean the working dimensions, but what may be called 'customers' dimensions, the length and height, and certain other dimensions of that kind. He had to translate those, and in view of that we issued a new circular in which our older line of engine dimensions were mentioned both in millimeters and English dimensions."



Another witness to the point that engines built by old measurement might be put on the market in metric terms was Col. R. E. Crompton who, in a discussion June 1, 1908, published by the Society of Engineers, London, said that he had the two systems alongside one another in his works; he was reported in part as follows:

“ If he turned out a steam engine of a certain size from his workshop, what would it matter that it had been designed in inches, although the purchaser might have it listed to him in millimeters? It would make no difference,” etc.

*Some Matters in which Coöperation with the United States Government is Wanted.* — Mention has been made of some branches of business in which there has been adoption of the metric system by the United States Government, the largest user of weights and measures. An obvious step remaining to be taken is to have the use of the metric system extended through any commercial transactions of the United States Government where it has not already gone. If the Government advertises for bids for an engine let metric measure be used for the dimensions by which it is designated. If bids are received for pipes let metric units be used to designate their diameters. Metric units have already been used to designate the caliber of rapid-fire guns in naval armament. Let the prices bid for food supplies, or for fuel, or for dredging material in rivers and harbors, be prices per metric ton or per cubic meter, etc. Our citizens have such desire to obtain government contracts that they will not fail to bid and to coöperate in the application of metric weights and measures. That these may be brought into use among the people generally is the chief benefit to be obtained from their exclusive use by the United States Government.

A very important step which needs to be taken in coöperation with the United States Government is to secure action by the separate states. They have to do a great deal of commercial business involving weighing and measuring; and old units ought to be abandoned therein at the same time as in the United States Government business. The teaching of the metric system to children in schools is for the state governments to attend to. The

verification and sealing of commercial weights and measures, and the detection and punishment of fraudulent weighing and measuring, are now in charge of the state and municipal authorities. Many details require careful attention in conducting a change; one illustration is that it has been usual to make metric weights in hexagonal form instead of in the round form common for old weights, this difference being a precaution against mistaking one set for the other. There is danger that, under the guise of changing to the metric system, rogues may try to set up some false weights or measures. The United States Government does not now have an organization suitable for looking after all the practical details throughout the country, and it would seem unreasonable for it to create one independent of the states.

*Some Matters completely within the Control of the United States Government.* — The United States has a postmaster in every village, and, by supplying them all with metric scales, could extend the change to the domestic service in the Post-Office Department. The citizens would not be likely to object, since 30 grams, the metric weight for a single rate, is nearly 6 per cent. more than one ounce. On the statute book for about half a century there has been the following provision (Section 3880):

“The postmaster-general shall furnish to the post-offices exchanging mails with foreign countries, and to such other offices as he may deem expedient, postal balances denominated in grams of the metric system, fifteen grams of which shall be the equivalent, for postal purposes, of one-half ounce avoirdupois, and so on in progression.”

This throws a sidelight on the problem of legislation. It was doubtless intended by this enactment to lead us to use the metric weight in the domestic service of the Post-Office Department; but the officials have treated it as simply allowing the old weight to be continued in use. It remains for a mandatory regulation to be adopted and for the weights and limiting dimensions of packages, etc., to be expressed metrically in all the published announcements and notices of the service; this has been too often neglected. The metric basis is securely fixed, having been adopted in the Postal Union treaty originally made in 1874.

Even opponents of its general use have admitted that it is the standard to which to refer various national reckonings in service like that of a clearing-house.

In coinage, the metric system has been introduced in the United States and in other countries. Our subsidiary silver coinage for forty years has weighed one gram per four cents; and our citizens could weigh their letters to determine postage required by balancing them against \$1.20 in subsidiary silver. A step that remains to be taken, however, is to get this fact thoroughly into the minds of the people; when a man gives or takes a half-dollar coin, he is not apt to think of its weighing  $12\frac{1}{2}$  grams or to have any thought of how heavy a gram is. I deem it highly desirable that upon the obverse of the subsidiary silver coins their weights in grams should be stamped. They go into everybody's hands; their design is absolutely in the control of the Government; the idea of associating coins with weight is of course ancient and fundamental. A weight somewhat heavier than a gram has been called a pennyweight; let us think of the weight of a gram in cents. The weight, 420 grains, was stamped upon the United States trade dollar, millions of which were struck about forty years ago for commercial purposes in the Orient. It may require an act of Congress to accomplish this.

Another thing which the Government can do is to use metric units exclusively in the Weather Bureau's announcements and charts, as it has heretofore done on the international charts. To use only kilometers for wind velocities and only millimeters for precipitation would bring these units into the minds of those who study the weather.

I will take up one more branch of business and that is the customs service, which might well be attended to in advance of most of the other applications of metric weights and measures, as has been the case in the introduction of the metric system in many countries. The collection of customs duties has to do with trade connected with foreign countries, and is in some degree detached from general domestic business. An executive order by the Secretary of the Treasury might establish the metric system, whether people liked it or not, in exclusive use in the

custom houses on short notice, merely enough to warn merchants to have their invoices prepared to meet the requirement. The existing law legalizing the metric system fixes the ratios by which conversions may be made from old customary units; and surely it would be a simple, though possibly monotonous, undertaking to calculate, if necessary, the metric equivalent of quantities of goods or rates of taxation expressed originally in terms of other measure. It is within the power of the United States Government to say what measure, established by it for many years, it will allow to be used in passing goods through its custom houses, as it is within its power to say what money it will accept in the payment of customs duties, refusing, for example, to accept British sovereigns or Mexican pesos or even its own "greenbacks," upon which it prints, "This note is a legal tender at its face value for all debts public and private except duties on imports and interest on the public debt."

*Our Immediate Opportunity.*— Ignoring or neglecting the matter would mean continuance of our annoyance and expense in hanging on generally to antiquated commercial units out of harmony with the metric system which is recognized as the established basis of all measurement. Not all of our fellow-men are so apathetic and inert as to let them be protracted indefinitely. The Second Pan-American Scientific Congress at Washington, in January, 1916, urged the thoroughgoing use of metric weights and measures as stated, on information furnished by the late Dr. Corthell, in the February JOURNAL OF THE BOSTON SOCIETY OF CIVIL ENGINEERS, Vol. 3, No. 2, p. 69. Dr. Corthell wrote, January 12, 1916, that the matter would be followed up, saying:

"... The opposition, which has been very strong and sometimes bitter, has gradually yielded, and one or two of the strongest opponents have seen a new light; and one of them is already an advocate of the metric system."

In the April *Munsey's Magazine*, a monthly which has a large circulation, there was an article entitled, "The Metric System," the tenor of which is indicated by its first sentence, reading thus:



"Pounds and ounces, gallons and quarts, tons and hundred-weight, miles and yards, feet and inches, acres and square feet, are making ready for their exit from the stage of American business affairs."

The article told about a bill for the promotion of that object being considered in Congress.

The *Ladies' Home Journal*, which claims a circulation of 1 750 000 copies, has in its number for May, 1916, a short article, entitled, "What Inches Cost," two sentences of which are as follows:

"It is estimated that if Congress would make the metric system the standard for this country it would save American business one hundred million dollars a year. . . .

"Scientists and many industrial establishments are already using the metric system; it is only a question of time before the householder will also enjoy its benefits."

The editor indicates that an account of the metric system can be obtained by any subscriber on application.

The metric reform has been vigorously advocated for years by the *Valve World*, the monthly publication of the great Crane Company, manufacturers of steam and plumbing supplies.

Are the members of the Boston Society of Civil Engineers modestly to efface themselves and to leave it entirely to the patriotism of the wholesale grocers, the magazine editors and others, to determine how the weighing and measuring of the United States is to be done? In his address at the annual meeting in March, the retiring president of the Society, Mr. Charles R. Gow, with commendable public spirit, referred to the desirability of engineers and engineering societies participating individually or collectively in attempts to influence or direct public affairs, mentioning that our Society had taken some steps in this direction by the creation of a legislative committee whose function it was to observe attempted legislation on questions affecting engineering (April, 1916, JOURNAL, Vol. 3, No. 4, p. 129). It seems highly desirable that a matter so important as this of the metric system should receive the attention of a special committee of the Society at the present time as it did during



many years, 1875-98. As to whether it was proper that the Society as a body should take positive action on the metric question, there was much discussion; and it has been recognized as clearly permissible for any statement or petition to receive the signatures as members of the Society of as many as please to sign it. Others might sign, as members of the Society, some different or contrary statement or petition if they preferred.

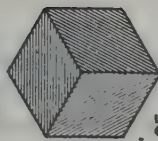
What should be prayed for? I have pointed out a few particulars of what I should like to have brought about by governmental action; but possibly the Society or a committee might think that a detailed program should not be prescribed in a petition, but should be left to Congress or the executive departments. Our purpose is to let the authorities know that we wish for the general result; the more citizens of intelligence and influence are known to favor it the greater the probability of vigorous action being taken. I recommend that members of the Society petition for an enactment that, from July 1, 1920, the metric system shall be exclusively used in all commercial transactions to which the United States is a party. I take the date from a bill introduced in Congress; any other date might be substituted. The date should be so fixed as to allow for the branch of business requiring the longest time; then let changes in other branches of government business be made as much earlier as seems fit to the officials in charge. This program resembles what was done by the American Institute of Electrical Engineers. Its resolutions favored the introduction of the metric system into general use in the United States at as early a date as possible without undue hardship to the industrial interests involved, and such legislation by Congress as shall secure the adoption of the metric system by each department of the National Government as speedily as may be consistent with the public welfare. The resolutions having been prepared by the Standardization Committee were by order of the Board of Directors submitted to the membership for letter-ballot; 1 569 votes were cast in favor and 178 against the resolutions; and it was ordered that notice should be given accordingly to the Congressional Committee in charge of the metric bill. This was in 1906, and reference may be made to the report of the Board of Directors printed in



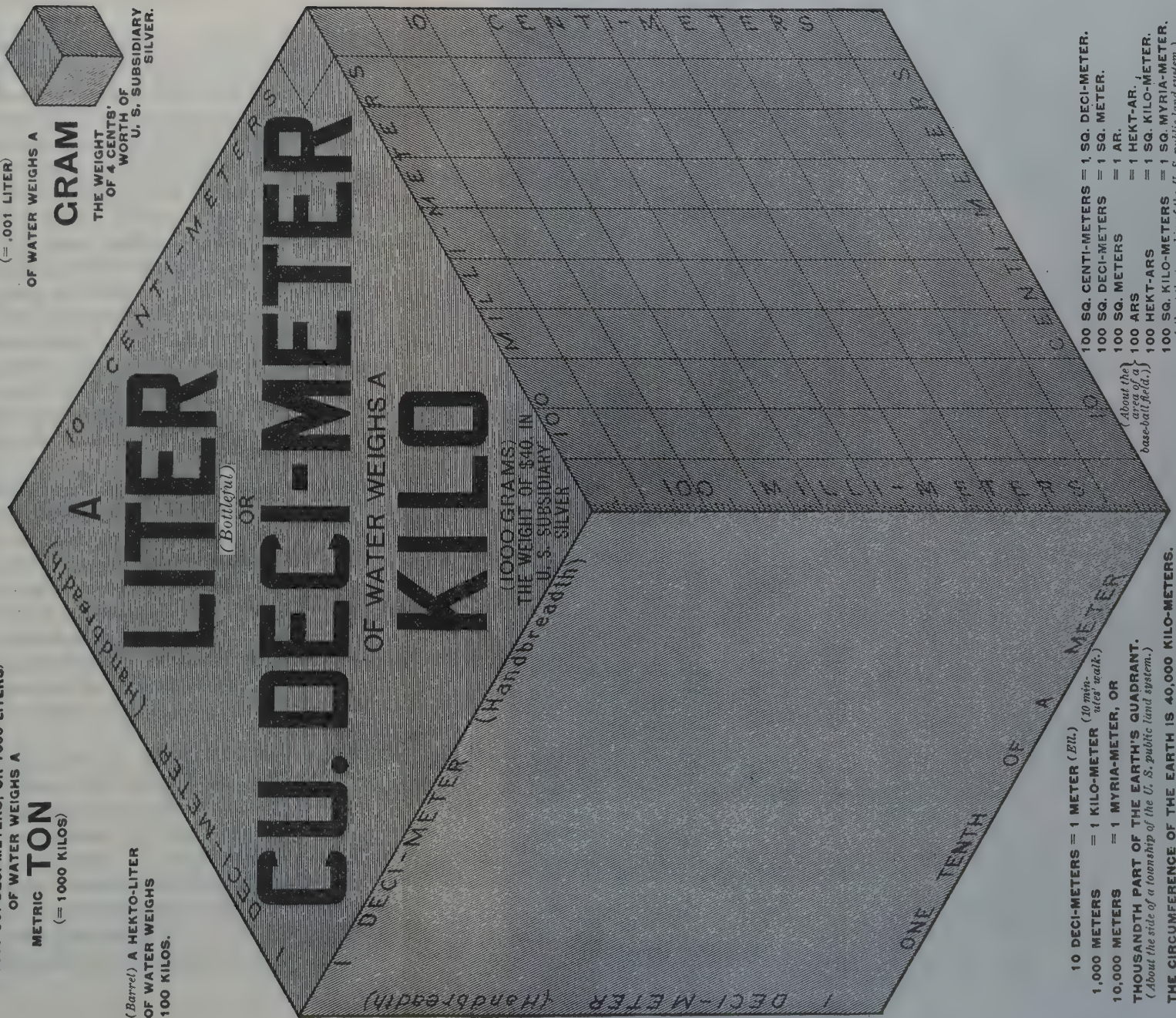
(*Tun*) **A CUBIC METER**  
 (= 1000 CU. DECI-METERS, OR 1000 LITERS)  
 OF WATER WEIGHS A  
**METRIC TON**  
 (= 1000 KILOS)

(*Barrel*) A HEKTO-LITER  
 OF WATER WEIGHS  
 100 KILOS.

**A CUBIC CENTI-METER**  
 (= .001 LITER)  
 OF WATER WEIGHS A



**GRAM**  
 THE WEIGHT  
 OF 4 CENTS'  
 U. S. SUBSIDIARY  
 SILVER.



100 SQ. CENTI-METERS = 1 SQ. DECI-METER.  
 100 SQ. DECI-METERS = 1 SQ. METER.  
 100 SQ. METERS = 1 AR.  
 = 1 HEKT-AR.  
 100 ARS  
 (about the area of a base-ball field.)  
 100 HEKT-ARS = 1 SQ. KILO-METER.  
 100 SQ. KILO-METERS = 1 SQ. MYRIA-METER.  
 (About the township of the U. S. public land system.)

10 DECI-METERS = 1 METER (*El.*)  
 1,000 METERS = 1 KILO-METER (*10 min-utes' walk.*)  
 10,000 METERS = 1 MYRIA-METER, OR  
 THOUSANDTH PART OF THE EARTH'S QUADRANT.  
 (About the side of a township of the U. S. public land system.)  
 THE CIRCUMFERENCE OF THE EARTH IS 40,000 KILO-METERS.



# АТЕМ-ИТЭО СІВУО А

(АТІТІ 100. -)

А СІВУО АТЕМ-ИТЭО

МАРД



МАРД  
АТЕМ-ИТЭО СІВУО А  
АТЕМ-ИТЭО СІВУО А  
АТЕМ-ИТЭО СІВУО А

# АТЕМ-ИТЭО СІВУО А

(АТІТІ 100. -)

А СІВУО АТЕМ-ИТЭО

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АТЕМ-ИТЭО СІВУО А

the June, 1906, Proceedings of the Institute, Vol. XXV, No. 6, p. 14, and to the *American Machinist* of May 26, 1906.

MR. WESTON.\* — That our present system of weights and measures is cumbersome and tied to the chaotic past, is conceded by nearly every educated man, but the adoption of the simpler and easier-used metric system is a matter of some difficulty, just as was the adoption of the dollar by our fathers, in place of the shilling. This required time. Even to-day a quarter of a dollar is "two bits" in some sections, and my respected grandfather always referred to a half dollar as four shillings.

The speaker is not going to debate the question of decimal *v.* duodecimal systems, and will admit the convenience of the latter to the architect, artisan and average man, when it becomes necessary to divide into halves, quarters, eighths, etc. The use of a scale divided into tenths and hundredths, which all of us use, may be acquired after a little practice, and the purchase of crackers and candy by the kilo is not a difficult matter if one has the price.

Those of us who have been brought up in the field have long ago discarded the link, the furlong, the rod, Gunter's chain and the like, and have used the mile, the foot and other decimals. To such, the use of the metric system would hardly pay for the change if the mile and the foot could be used apart from other measures; but such is not the case, and those of us who have worked in engineering laboratories know perhaps better than anyone else how much time could be saved by the metric system, which, as you know, presents the frequently lost-sight-of advantage of the same unit for lineal, surface and capacity measures and volumes.

With the metric system in use, we all would really know our weights and measures, as even the educated among us do not at present. How many among you know the weight of a scruple, a karat, a dram or a pennyweight, or that the troy ounce is heavier than the avoirdupois ounce? In fact, most of us know what we use and little besides except as our memories may retain something we acquired in our grammar-school days. Chemists and electrical engineers have long used the metric system, and

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\* Of Weston & Sampson, Consulting Engineers, Boston.

even among civil engineers the term "kilowatt-hour" has now no terrors for anyone.

To my mind, the interchangeability of weights of water, measures and volumes is the greatest advantage of the metric system, and well worth whatever pains are necessary to bring it into daily use among us. Take a class of computations we make frequently in our office, an example of which is the following: To a tank of water 40 ft. long by 30 ft. wide by 11 ft. deep, how many pounds of, say, lime must be added to be equivalent to 60 parts per million?

By the United States system, we multiply the dimensions and obtain 13 200 cu. ft.; then this must be multiplied by 7.48 to obtain 98 600 gals.; then we multiply 60 parts per million by 8.34 to obtain the equivalent number of pounds per million gallons, namely 500.4. Then the quantity to add to 98 600 gals. is 9.86 per cent. of 500.4 lbs., or 49.7 lbs. per million gallons. We have no avoirdupois scale with the pounds graduated in tenths, so we multiply 16 ounces by  $\frac{7}{10}$  to get the ounces and fractions, and arrive at 11.2 ozs. The total amount to be added, to the nearest quarter ounce, is therefore 49 lbs. 11 $\frac{1}{4}$  ozs.

Take the same problem when the basin is 12 meters long, 9 meters wide and 3.3 meters deep — these measures being approximately equivalent to the ones just given. The product of these three dimensions is 356 cubic meters. This is 356 metric tons of water, or 356 000 kilograms, or 356 000 liters. Sixty parts per million is 60 milligrams per liter, or 60 grams per ton, or 60 grams per 1 000 kilograms. Therefore we can obtain our results in grams by simply multiplying 356 by 60, which equals 21 360 grams, which, divided by 1 000, is 21.36 kilograms.

In all water filtration operations, the metric system greatly facilitates computations, and the same would be true of all hydraulic computations involving the factors 62.4, 7.48, 8.34, etc. The speaker has decided that in the next water purification or sewage disposal investigation he will use the metric system entirely and convert the results into United States equivalents at the end, and thus make a great saving in computations during the investigation.

Savings in time may be made in other computations than



the ones mentioned. Take, for example, the conversion of pounds per square inch of water pressure into feet of head. Now we have to multiply by 2.307, but one kilogram per square centimeter is the head produced by 1 000 cubic centimeters of water, which is equivalent to a column of water one meter long with a cross-section of one square centimeter. Therefore one kilogram per square centimeter is equivalent to one meter of head.

Other computations are equally simple. The kilowatt-hour is 1 000 watts, and the metric horse-power, which is within two per cent. of our present standard horse-power, is equivalent to 75 kilogram meters per second.

Before the metric system can be adopted, there must be difficulties. Men and machines exist, and our present system is tied to them and their past. Ample time should be allowed for the change and for the education of the users. If the more logical and simpler metric system can be brought into use, I believe that many of the units are so near the older units in value that some of the older names will be retained for a long time. Thus we may expect to have 500 grams called a pound, 250 grams a half pound, a liter a quart, and the 2 206-lb. metric ton replace the 2 240-lb. long ton. Again, 300 centimeters is nearly a foot; the metric and United States horse-powers are practically the same, and one B.t.u. is about a quarter of a calorie.

Those of us who use measures or weights of one system almost exclusively do not appreciate the difficulties of our present system, as well as those of us who have to use laboratory results and electrical data based on the metric system in conjunction with the present system of weights and measures; and if we lived in England our plight would be worse. They say that the English are the best mental arithmeticians in the world. They have to be, for with their 14-lb. stones and 112-lb. hundred-weights and all, they must have to make prodigious efforts to keep pace industrially with competing European nations. Those of us who have seen an English set of books or an English engineer's computation sheets, realize how much more time they lose than we, and we lose much more than the French, Germans and South Americans.

The speaker firmly believes that the United States must use the metric system if we are to become an efficient world power and enter with the least friction into the markets of the world. When one takes a little time to master the system, its extreme simplicity and universality become plain. How little time is really required was exemplified at one of the largest chemical manufactories in New England, whose vice-president told the speaker that it took but a few hours to teach ordinary laborers to read meter rules and meter and kilogram gages.

Like many another good thing, the American birth of this system must be attended with considerable pain, but I, for one, am sure that the result would be well worth the labor required to bring it into our professional and private lives. Individual effort cannot introduce the system, however. The Government must take action in its own departments, and let the rest of the country gradually fall into line.

MR. PARKER.\*—I have been deeply interested in the metric system for many years. My business is structural steel work and we use feet and inches, and we are not afraid of thirty-seconds and sixty-fourths of an inch. We must work accurately. Engineers are sometimes satisfied with the hundredth of a foot, not so the bridge builders.

There is no question of the beauty and utility of the metric system, and we ought to use it. About thirty-five or forty years ago, I was fascinated with the whole system and gave some illustrated talks on the subject to lyceums and young people's associations. I made wooden models of the meter and cubic decimeter, the latter marked off into little cubic centimeters and divided into sections to be taken apart to show the deciliter, centiliter, and milliliter. I made a tin liter that was just filled by the cubic decimeter, and a tin milliliter to hold a cubic centimeter of water or one gram in weight. With these models, a half hour sufficed to give an intelligent idea of the system to young and old in an audience. They would grasp it quickly, and some have since told me they never forgot it. It is not made interesting in our schools. High-school pupils have told me that they hate it. I think it is because the book tables are filled

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\* Supervisor of Steel Work, Boston Transit Commission.

with long fractional values in the English system. The metric system is very simple. I tell all that I talk with that the metric units are one tenth larger than the English; the meter, a yard and a tenth; the liter, a quart and a tenth; and the half kilo, a pound and a tenth. That is the simplest way I know. We must learn to think in the metric dimensions and sizes. In teaching, don't dwell on the English values, but just hold up the meter and liter models and show that there are only four unfamiliar names absolutely essential to learn, viz., the meter, the liter, the gram, and the prefix "kilo." When they see that these names mean, in order, measure, quantity and weight, and "kilo" 1 000, they realize how simple it is. The deci, centi and milli prefixes we have in familiar use in our dimes, cents and mills. We hear little about dekameters and hektometers and myria-meters, but much about meters and kilometers. We seldom speak of the yard, but often of feet and miles. I think it was in 1796 or 1797, when John Adams was President, that the metric system was legalized in the United States.

MR. BROOKS. — The metric system was legalized in 1866.

MR. PARKER. — I thought I had read that John Adams recommended it.

MR. BROOKS. — Jefferson, when Secretary of State under Washington, made a report, but I think it was not the metric system. John Quincy Adams, Secretary of State 1817 to 1821, published a very elaborate report. It was a very learned and elaborate report and discussed the metric system to very great length. But the system was not legalized until 1866.

MR. PARKER. — I have talked with some of my workmen about the metric system, and they speak against it. It is because they don't know about it. When you learn it and see the saving of time it effects, you long for it. The other noon I spent a few minutes in telling a carpenter, a template maker, and some other mechanics about it, and they got much interested. They will not forget it. They didn't know what it meant before, and hadn't realized that it was the familiar dime, cent and mill applied to measures. It seems to me the first important thing is to have people know what it is, and anything to promote that will be very helpful. I shall try to convert more of those work-

men who are against it. I saw an absurd article in the *Herald* the other day, against the metric system. The writer evidently didn't know the details of the system correctly. I think it would be a good idea for Congress to set a date on which the system will be compulsory, and then we will adjust ourselves to it. If there was a date set, the different firms would anticipate the day and have everything ready, and the system would come into use naturally and rapidly. The difficulties now seem formidable to many. So far as scales are concerned, there are now many balanced scales in use. We have them in chemical laboratories and in many stores, and either metric or the English weights can be used. All the graduated scales would of course need new beams or new drums. Scales with revolving beams giving the metric or English weights are now used by the post-office in weighing parcel-post matter. The greatest difficulty that I see in the mechanical world is the changing of our taps, dies, threads and gages, but we would rejoice when the numerous gages and threads now in use were replaced by one uniform standard. A customer going to a store would soon learn to ask for a liter instead of a quart. With the English system we had three quarts in use, — wine, beer and dry. A while ago the wine quart drove the beer quart out of use, being the smaller. To show the saving of time, take for instance articles billed with prices per square foot. Dimensions of, say,  $7\frac{1}{8}$  ins. wide and 3 ft.  $6\frac{5}{8}$  ins. long, and various other sizes. First you must reduce all these inches and fractions to decimals of a foot, and it takes quite a while to figure a bill with fifteen or twenty items on this basis. If it were in metric dimensions, how simple it would be, being in decimals from the start! You know at once in the metric system what a thing weighs if you know its dimensions or bulk. It is beautiful.

I suppose it is too late to consider any other decimal system, as I believe there are about thirty nations now using the metric system. In the Waltham Watch Factory the metric system is used exclusively, and the paper manufacturers are fast coming to sell their goods by the hundred. Reams and quires are being done away with. The metric system is coming, but the Government could hasten it. German manufacturers will make



drawings for steel work with the English dimensions for the sake of getting trade here and in England, furnishing the steel work ready to erect. I think we ought to get everybody familiar with the metric system. Most people, when they know about it, are delighted. To have people want it they must first know what it is, and learn how simple it is, and how much time it saves. Mr. Brooks thinks we should work as individuals instead of as a society. But I think that all engineering societies and other bodies, such as boards of trade and chambers of commerce, who see the benefit which would come from the change, should urge Congress to act. Petitions also should be prepared and signatures obtained by the thousands and presented to Congress. The individual work will prepare the public to bring pressure on the Congress. I have always thought it was a pity that the world didn't have the duodecimal system instead of the decimal. Instead of stopping at nine characters or figures have two more, say, an inverted 7 ( $\angle$ ) for the tenth character, and an inverted 5 ( $\text{S}$ ) for the eleventh character, then the zero for the twelfth. This would enable us to make divisions without remainder or fractions by one, two, three, four, six, and with simple fractions by eight and nine, whereas the decimal system admits only of divisions by two and five.

MR. ADAMS.\* — When I opened an office in 1879 I thought so well of the metric system that I wanted to do what I could to advance it, and I did actually take measurements with the meter as the standard, and in order to give my clients what they wanted I added the feet and hundredths; but all the work was done metrically. I put the dimensions on plans in meters, and decimals, and then in parentheses put in feet and hundredths. Of course all the measures, that is the steel tapes, were in decimal divisions, even the feet; but I found no difficulty with my assistants in the use of the meter, although they were taught entirely with the use of feet and hundredths, or feet and inches and sixty-fourths. They really seemed to feel a kind of relief to get on something that didn't get all mixed up. Of course, that didn't apply to feet and hundredths, but it did apply to feet, inches and sixty-fourths. I kept that up until I went to work for the Gov-

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\* Landscape Architect and Civil Engineer, Boston.

ernment, although I didn't entirely use the meter the latter part of the time. It was in 1885 that I went to work for the Government, in the lighthouse service.

The most practical difficulty that I had was in getting a really good metric measure; that is, the metric steel tapes were not as good as the other steel tapes in feet and hundredths. You couldn't get them as good then. It wasn't so much that my metric tape wasn't accurate, but the steel wasn't as good to work with. It was too soft; the figures wore off. It wasn't the fault of the system; it was simply the fault of those who were trying to sell the measures. I had office furniture made and had the drawings made metrically, and simply took a meter stick, that cost me seventeen cents, I think, and handed it to a carpenter who hadn't seen one before and told him to make a table. It had round edges and was rather complicated with a large number of drawers. The carpenter had no difficulty whatever. I asked him afterwards whether it bothered him any, and he said no, all he had to do was to take the meter stick divided and use the figures on the drawing. I found the practical difficulty in actual use in being obliged to change into the common or accustomed system, and that introduced extra expense in work that had to be given in feet and hundredths or feet and inches. On that account I gradually dropped the use of the meter and took the feet and hundredths, because that would be more readily changed either way. I was with the Government about nine years. All work I have done since then has been with the feet and hundredths. But, on some work I have been doing the last week, if I could have had the metric system and the client had understood it, a great deal of misunderstanding, slowness in figuring, and so on, would have been saved. The work related to the introduction of a water supply, where we had the cast-iron pipe in feet and tons and under 100 lbs. pressure or under 231 ft. head. If we had been talking on the metric system, we should have saved ourselves considerable time and understood each other a good deal more readily.

MR. BROOKS.\* — I heartily concur in the opinion expressed by Mr. Weston, about simple relationship between different

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\* Author's closure.

units, and think that that constitutes the greatest advantage of the metric system. That it is not more generally appreciated by those who have tried the system only in awkward connection with other measure is like a painting not being appreciated by a blind man or music not being appreciated by the deaf. They are so accustomed to our old units, surviving from various ancient systems and brought into inharmonious contact with one another, that they don't ordinarily realize what it means to have units related in one system. The systematic character of the metric weights and measures makes them easier to learn and remember, causing great saving of effort and expense in school-teaching; gives better mental grasp of magnitudes and quantities numerically expressed; makes it simpler to calculate about them; and enables us to dispense with numerous tables that have been used in dealing with incongruous old measures and have been liable to contain errors and to have been out of reach when wanted. This advantage, which might well have caused the use of the metric system everywhere, has had little influence upon commercial traffic; what has caused such commercial use as has been brought about is chiefly the requirement of our relations with foreign countries, regardless of whether it was liked or not. That international intercourse furnishes great occasion for introducing the metric system is illustrated by several items before mentioned; also by the agitation of the subject in Great Britain, about which I will now speak.

It is quite possible that Great Britain will bring about the completion of the metric reform sooner than the United States will. Over there, at the meeting in February, 1916, of the Association of Chambers of Commerce, the following resolution was passed:

"That this Association strongly recommends all manufacturers, merchants and traders to adopt the use of the metric system in price lists and invoices in all transactions with countries using that system, and that the Executive Council be requested to invite all chambers of commerce to make a report as to the best means to be adopted for the purpose of introducing a decimal system of coinage into the United Kingdom."

In the Decimal Association's annual report, of which men-

tion has been made, special prominence was given to the proposition that to capture South American trade Great Britain must use the metric system. The report included a similar suggestion of assistance to be afforded to British firms in competition with foreign countries in referring to resolutions favoring the adoption of the metric system from the Council of the British Horological Institute in May, 1915, and the Report of the Committee of the London Wholesale Jewellers and Allied Trades' Association in February, 1916. The following sentences also may be quoted from the Decimal Association report:

"One of the results of the war is the remarkable extent to which the metric system is being assimilated in the life of the nation. The presence of our military men in France and Flanders, and of Belgian and French refugees in our midst, has helped to this end. The nation has already had to experience so many violent changes that it is more ready than formerly to entertain proposals of reform. . . .

"A proof that more individual firms are using the metric system in their business is the fact that, in 1915, 38 373 metric weights and measures were submitted for testing in the city of London. Only a few years since the number was under one hundred per annum, and in 1914 was 1 741."

The report also tells of a canvass made by the *Electrical Review* among electrical engineering firms, in which, excluding the doubtful, there was a majority of four to one in favor of the general adoption of decimal coinage and the metric system in Great Britain; and of a similar canvass with like result made by Richard Klinger & Co. among engineering and kindred trades.

The conspicuous thing in recent British propaganda is the inclusion of money in the proposed decimalization as just now mentioned. For twenty years the Decimal Association was postponing the subject of money, while pressing the metric reform involving weights and measures; but it now urges the decimalization of money, taking as the unit one tenth of the pound sterling. One condition favoring the accomplishment of this project is that it permits the continuance in use of nearly all the existing gold and silver coins with some changes of name. The unit, having twice the value of the shilling, is represented by the current florin silver piece introduced in 1849 with the



inscription upon it "one florin, one tenth of a pound." Though that inscription had been omitted in more recent coinage, the original intention evidently was to promote decimal reckoning. The sovereign is thus a piece of ten florins: the half-sovereign, of five florins; the shilling is  $\frac{5}{100}$  of the florin, or 50 cents; and the sixpence becomes 25 cents, or a quarter of a florin. Among the proposed new nickel and bronze coins, one is of unusual denomination, namely, a 4-cent piece, or twenty-fifth part of the florin, the purpose of which is to take the place of the present penny, or twenty-fourth part of the florin, because that has been so prominently in use for petty payments.

The inclusion of money offers the advantage of correspondence in arithmetical progression of weights and measures with money, a similar advantage to that which I was just now expatiating upon as not justly appreciated by our people generally. We may well take heed of this as a stimulus to quicken our riddance of old units in commercial transactions in the United States. Allow me to quote a single sentence from the report of the Boston Society of Civil Engineers' Metric Committee, dated October 15, 1884, as printed in the *Journal of the Association of Engineering Societies*, Vol. V, p. 30, as follows:

"In Sweden, in 1848, Mr. Wallenberg opposed the decimalization of money without weights and measures, because a visit of three years to America had shown him how inconvenient in business is a duodecimal system of weights and measures combined with a decimal currency."



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**BOSTON SOCIETY OF CIVIL ENGINEERS**  
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**DISCUSSION OF "REFORM AND REGULATION."**

By MESSRS. D. C. JACKSON, F. P. STEARNS, A. R. WEED, J. P. SNOW,  
S. E. THOMPSON AND A. C. HUMPHREYS.

MR. JACKSON.\* — Our present-day commission control of public service corporations — which is the main subject that the distinguished and able speaker of the evening has taken for illustrating his theme — is young. It is found in more than 40 states, some of which are old and fairly conservative, and others younger and less conservative. In certain few of the states, commission control of the public service companies has been in vogue for several decades, but in most of the states it has been a matter of but few years. Under such circumstances it is not unexpected that sharp differences of opinion arise under commission procedure, and also that differences of practice arise as between the commissions themselves, for a fixed basis for judicial consideration of commission cases has not yet been established. In fact, such a fixed basis cannot be established until men who are in touch with the affairs which come within the perview of these commissions have reached agreement upon fundamental principles. I may be permitted to express regret that the distinguished speaker of the evening did not lay before us an analysis of such principles which his wide experience would lead him to formulate. Lacking an accepted set of definitions of the duties of the public service corporations to their patrons, other than the contradictory statutes of our various states and a few pro-

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visions of common law not yet swept away by the deluge of statutes from our legislative halls, thoughtful men fail to find common ground for their minds to meet, and heedless empirics are under no restraining influence in their utterances.

Part of the difficulties set forth by Dr. Humphreys rest on the lack of understanding on the part of the average man of (1) the difference between a small business, like running a corner store, with the proprietor in personal relations with his customers, and a big business which employs thousands or tens of thousands of men whose sales employees only get in touch with the customers, and (2) the difference between a business which turns over its capital from one to five times a year like a mercantile business, and a business that turns over its capital only once in from three to ten years — like a public service business. These differences the average man will never understand until he has had some of the corporation securities and comes to appreciate the situation by studying it from the inside as a part owner.

At the present time there is an unfortunately small percentage of the nation's population directly owning a part in the public service corporations of local and national import. The number of stockholders of the steam railroads in the United States, according to the Interstate Commerce Commission, is under 625 000. This is an impressively large number of people when considered by itself, but if each one of 625 000 stockholders represented a separate family, it would include only about three per cent. of the families of the United States. There are probably three times as many families represented in operating the railroads. A wider distribution of corporation securities among the people of the nation would be serviceable both to the people and to the corporations, by bringing closer relations and more intimate understanding. Indirect relations, through the savings banks and the insurance companies of which Dr. Humphreys speaks, do not serve the same end as direct ownership. Some of the more general spreading of the securities which is desirable might be accomplished if the corporations would issue their stocks — and more particularly their bonds — in smaller denominations, as the French government does its government notes called *Rentes*.



Some may wonder why corporations are formed. They are formed because in these days of industrial affairs industries must be so big for the purpose of economy of production that no small group of men can or will undertake to handle them, and consequently it is necessary to have some coöperative arrangement whereby hundreds, thousands or ten of thousands of individuals may conjointly provide funds to make up the necessary capital. A corporation is simply a large enterprise intended to be run on a representative basis. If the management sometimes becomes rather more like machine politics than true representation, that is a thing that may be and should be reformed; but it is no reason to charge that all corporations are wrong because some have done wrong.

The whole theory of modern economics is built up under the influences which were introduced by the development of steam power, bringing into the service of humanity the very potent agencies of the steam railroad, ocean navigation, the telegraph, the telephone and the general use of mechanical power. These are engineering industries, and when it is remembered that the great Rainhill experiment, in which George Stephenson proved that a steam engine could beat horse traction, occurred as recently as 1828, it will be recognized that the railroad is young. The telegraph is younger, the telephone is still younger, electric light is in its babyhood and electric power transmission has hardly been germinated. Under the circumstances it is hardly to be expected that the final economic theories should yet be worked out for the new conditions under which we now live.

The engineers are responsible for these economic changes that have produced the large corporations, and it is doubtless right that we should undertake some of the responsibility for seeing that they are made most serviceable. The progress of corporations or their equivalent cannot be prevented. The great corporation is one of the manifestations which accompany the improved means of convenient transportation and speedy telegraphic intercommunication which are characteristic of the age in which we live.

Men of this age of course do not desire to relinquish the

benefits of these improvements, and we have got to adjust our processes so that we may realize the advantages to the full, and ultimately do away with any disadvantages which cling to the economic structure. There are various means of accomplishing this, but it is not necessary to go into them here. Statesmen and others will have to work them out, though engineers may aid. If corporations could be protected from unfair attacks made by the ignorant or by persons looking for personal gain, the barriers complained of by Dr. Humphreys would be overcome, but that cure requires a long step forward. To make it, demands competent government supervision of all corporations dealing in a large way with the public, which imposes upon them, and upon utilities companies particularly, luminous public statements of their business; and it equally demands that the public shall yield justice to corporations with the same degree of completeness as the individuals of the public seek it for themselves. For accomplishing these two things we now have to rely to a considerable degree upon government commissions. If these commissions do not succeed in accomplishing these ends, they will be swept away and some other form of procedure put in their place; but for my part I believe they have it in them to succeed, and that various ones are succeeding.

As far as the public service corporations are concerned, they are the natural outcome of the demand of the civilized world for convenient transportation, rapid intercommunication and ready distribution of power. They compose a comparatively new and mighty force in the social order. Of course this force must be prevented from dominating or warping the social organization, but there is no danger of public service corporations becoming despots, as is now and then the apparent fear of some people, provided they are kept under proper restraint, and society cannot afford to make restraints which are of themselves unnecessary and unfair. These corporations serve a very beneficial end in our lives, and their rights are as well founded, and should be as well secured, as the rights of any citizens who are individually or collectively bent upon any proper business pursuits.

To further the cause of understanding, I will now lay before you six principles such as are referred to above, the general

recognition of which would do much to give common ground for adjustment of differences of the nature that Dr. Humphreys complains of:

1. The company is granted certain special conditions by the public for the purpose of enabling it to furnish readily some type of service to the people, and it should be expected to furnish service fitting the needs of the people, good of its kind, and at prices which are reasonable when judged by the conditions.

2. The company must not be unnecessarily harassed by rules and regulations, but must be afforded every reasonable opportunity for economically transacting the business rightfully related to giving the service for which the company was organized; and it must be allowed to make such clear profits over all legitimate costs of its service that it may attract the best, fairest and broadest minds to the management, and maintain a position of stable credit with the investing public.

3. A public service company in a new and developing territory must see before it opportunity to earn returns on its invested capital which are large compared with those adequate in stable and thickly settled regions, in order that it may secure the capital needful for developing its plant and extending the service to meet the apparent needs of an expanding and not yet stable population. If opportunities for honestly earning large returns on the investment in a new territory are curtailed by legislation, the development of the service must inevitably become retarded, to the disadvantage of the territory and the inconvenience of the population.

In this connection it is pertinent to refer to the rate of ordinary interest in relatively new communities. Within two decades, for instance, the ordinary interest on bank loans with good security was ten to twelve per cent. in Colorado. Even now it is six to eight per cent. in Wisconsin.

4. A new project even in a stable territory ought to earn more than current rates of return for its investors whose enterprise prompts them to take the risks of establishing the business, but the return on the investment may be expected finally to come to current rates after the business has become firmly established on fixed franchise rights covering a long period.

5. A private corporation operating under a short-term franchise must have rates which are sufficiently high to provide an amortization fund which will reasonably insure the company's ability to return to the individual stockholders their original invested moneys in case the franchise is not extended. Otherwise, there is confiscation. A short-term franchise, unless accom-

panied by an agreement for purchase of the property at the end of the term, is therefore ordinarily not a provident grant for a public body to make; but a term franchise with an agreement to purchase the property if the term is not extended, or an indeterminate franchise such as obtains under the public service statutes of some of our states, is more to the advantage of the public since it makes a more efficient basis for conducting the business.

6. The bookkeeping for a public utility should scrupulously distinguish between capital expenditures and operating expenditures (including within the latter, expenditures for renewals of plant required to be made as plant depreciates in order that economical and good service may be maintained).

MR. STEARNS.\* — Dr. Humphreys attacks the problem of reform and regulation from many points of view, but I think he makes it clear that he recognizes the necessity for the regulation of public utilities which are practically monopolies. He leads us to infer, however, that he believes that regulation as now conducted by legislative bodies is very bad, and that regulation by public service commissions differs from that by legislative bodies only in that it is less bad. He says of federal and state commissions, after referring to their good and bad work, "If a fair analysis were made of the complete record of their activities, I can hardly believe that the balance would be found in favor of the commissions."

I think all agree that regulation has come to stay until that far-away time when corporations will not ask for more than is justly due them and the people will not strive to award them less than their due; also that regulation by a legislative body must necessarily be defective because a legislative body has neither the time nor the qualifications for reaching equitable results in a matter which is so intricate as a regulation of public utilities. The practical solution of the question, therefore, is regulation by commissions.

It is hardly to be expected in a democracy that the members of commissions in all cases will be selected with reference to their fitness to deal fairly and equitably with the companies which they are to regulate. Some will unduly favor the public, and

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others the companies. My acquaintance with the work of public service commissions, obtained by reading their decisions in cases brought before them, by their technical discussions of subjects related to their work, and by personal contact, has led me to believe that in the great majority of cases they intend to be and are fair to the public service companies.

As I learn the claims made by public service companies in various cases, I am led to question whether the point of view of their representatives is not affected by the failure of the public service commissions to accept their inflated claims as to the value of the property in question. Some of the views expressed may be illustrated by quoting the decisions of public service commissions and by referring to the testimony brought before commissions and courts.

One of the fundamental principles definitely established by the United States Supreme Court is that a public service company should be permitted to earn a fair return upon the fair value of the property used by it for the convenience of the public. Although, under the law as laid down by the Supreme Court, the California Railroad Commission might have excluded an important property which was suddenly thrown out of service and was no longer used "for the convenience of the public," it made its decision on equitable grounds (3 Cal. R. C. R., July 29, 1913, pages 1051-1052):

"It seems fair, however, to permit the defendant during each of the ensuing ten years to collect rates high enough to permit it to charge off such sum on its books that by the end of the ten years the principal so charged off, together with the interest, shall have amounted to the entire value of the line at the present time. I believe that it will be very liberal on the part of the rate-fixing authorities to permit this to be done."

The Michigan Railroad Commission, in a decision as to the capitalization of certain lands purchased for a reservoir in connection with a hydro-electric plant, stated that it was "satisfied from the record that the sum of \$500 000 would amply cover the cash outlay for the purchase of the land," but it took into account the long time (about eleven years) required to obtain the lands in a case where the company did not have the right

of eminent domain. It also recognizes the various expenses incurred by the promoters, and permitted the capitalization of the land in the sum of \$1 450 000, made up as follows (Orders and Opinions, Mich. R. R. C., Vol. 2, No. 1, page 25):

|                               |             |
|-------------------------------|-------------|
| Original land cost.....       | \$500 000   |
| Service in acquiring.....     | 500 000     |
| Interest during purchase..... | 150 000     |
| Cost of promotion.....        | 300 000     |
|                               | <hr/>       |
|                               | \$1 450 000 |

Many other decisions made by commissions might be quoted to show their tendency toward liberal dealing without taking advantage of the technicalities of the law to diminish values.

One of the things which has led to the greatest difference of opinion between representatives of the companies and the commissions I believe to be the adoption of theories in common use in valuing the property by the cost of reproduction method. It is generally admitted that, subject to some exceptions, a property which has been built or acquired within a few years of the date of the valuation should have a reproduction cost and a value substantially equal to what the property cost, and this rule should apply not only to the direct cost of the property but to the overhead charges as well. Proper theories for determining overhead charges should therefore give results which will conform with actual charges in respect to recently acquired property, if not in other cases.

As illustrating cases where theories commonly used do not give this result, I will refer to a case where an appraisal was made in a given year and again five years later. One of the engineers who took part in the original appraisal brought it up to the later date by adding the expenditure for construction during the five-year period, as shown by the books, and made an allowance as an overhead charge for the interest during construction, which was not included as a construction charge in the book accounts. The allowance which he made was \$48 000, which was practically the charge actually incurred in connection with the property built during the five-year period.

Another engineer, adopting the theory that in obtaining the reproduction cost the property should be considered as non-existent and to be reproduced in one construction period, found that the interest during construction equaled 8 per cent. of the total reproduction cost of the whole property, exclusive of interest. Applying this percentage to the part of the property built in the five-year period, the amount attributable to it was substantially \$152 000.

In connection with this same property, the item of "development expense" or "going value" was under consideration. One engineer adopted the view that the going value of the property at the later date of valuation was at least as great as five years before, making the allowance for going value on the property built within the five-year period practically zero, and this probably agreed fairly well with the actual development expense during this period.

Another engineer, estimating the going value in accordance with a commonly adopted theory, included \$200 000 in the reproduction cost as the amount attributable to the property added during the five-year period. It is worthy of note that the evidence above mentioned was all given by engineers on the same side of the case.

When commissions are confronted with such varying evidence, it is not surprising that they adopt the figures which agree with actual expenditures in recent years, but this is likely to result in not well-founded criticism by those who believe that values determined by established theories should control.

Illustrations similar to those given above are furnished by two cases which were brought before the Public Service Commission of the State of New York, Second District. In one of these, *Fuhrmann v. Cataract Power and Conduit Company* (3 P. S. C. N. Y., 2 D., page 710), the Commission said:

"According to the witness . . . the cost, as it might be termed, of acquiring the business of the phantom plant was \$1 000 000. Apportioning this cost to the business acquired during the last five years, we find that upward of \$500 000 of it is assignable to that period, while the expense actually incurred was \$34 004. It may be answered to this that the expenses

were incurred during the previous history of the company. There is nothing, however, to show that this is the fact, and an analysis of the accounts of the company would show that it is not a fact."

In the second case, that of *Fuhrmann v. Buffalo General Electric Company* (3 P. S. C. N. Y., 2 D., page 739), the Commission reproduces a table (page 749) which was prepared by a witness for the company as an estimate of the cost of reproduction of various parts of the physical property, which gave in detail the overhead charges applicable to each part. From this table the Commission selected for illustration 3 000 municipal arc lamps, purchased after the company had been in existence for years. Its tabulation of the cost and overhead charges is as follows (page 750):

|                                                 |            |             |
|-------------------------------------------------|------------|-------------|
| 3 000 municipal arc lamps at \$21.70.....       |            | \$65 100.00 |
| Engineering and supervision, 5%.....            | \$3 255.00 |             |
| Organization of business, 6%.....               | 4 101.30   |             |
| Taxes and interest during construction, 4%..... | 2 898.25   |             |
| Piecemeal construction, 10%.....                | 7 535.45   |             |
| Promoter's profit, 5%.....                      | 4 144.50   |             |
| Brokerage, 1½%.....                             | 1 453.46   | 23 387.96   |
| Total.....                                      |            | \$88 487.96 |

The overhead charges in the table amount to 36 per cent. of the estimated cost of the property units, and do not include going concern value, for which the company claimed a large sum.

Commenting on the overhead charges, the Commission said:

"We are unable to understand, and no explanation has been offered us, why a company which has been in existence for years should be entitled to charge a promoter's profit of 5 per cent. upon new arc lamps which it buys for its service. We are also unable to understand why a 10 per cent. charge, amounting in this case to \$7,535.45, is proper for piecemeal construction in the case of buying 3 000 arc lamps at one time."

It seems clear that theories which give values far in excess of actual expenditures will be given up when valuation matters are better understood; but in the meantime they support inflated



claims, and much hard feeling is engendered because these claims are not recognized.

Dr. Humphreys presents the view that the deduction of depreciation from the value of a plant in rate-regulating cases necessarily means confiscation.

In any continuous system of regulation such as now prevails in the case of railroad, telephone and many other companies, the equitable treatment of depreciation requires a consideration of the amounts that the companies are permitted to earn and required to set aside to cover the lessening value of their perishable property.

The fundamental principle relating to depreciation in connection with such regulation is that the company, in addition to being permitted to earn a fair return on the capital invested in the property, shall also be compensated for the loss of capital value due to the depreciation of the perishable property as it grows older. Various methods of accounting for this loss of value have been adopted and are now in force under the authority of the public service commissions.

In railroad accounting in the past, and to a considerable extent at the present time, the theory has been that sufficient rates shall be earned to compensate for the loss in the value of property units at the time they cease to be useful. Under this theory the rate payer is not supposed to furnish any compensation for the loss of value of a property unit as it accrues, but to furnish the full compensation at the time it ceases to be useful. This is known as the replacement method of compensating for depreciation.

In the case of the telephone companies, the prescribed accounting methods are different. The companies are required to make depreciation charges each month or year "to cover the expenses of depreciation currently accruing in the tangible fixed capital," and it is required that the rate of depreciation shall be so fixed "as to distribute, as nearly as may be, evenly throughout the life of the depreciating property the burden of repairs and the cost of capital consumed in operations during a given month or year, and should be based upon the average life of the units comprised in the respective classes of property."

The amounts which these companies are permitted to charge as a depreciation expense is a recognized factor in determining the rates which the public must pay, and that these amounts are not small may be seen by reference to the Annual Report of the Directors of the American Telephone & Telegraph Co. for the year 1915. This report gives a combined statement for the Bell Telephone System in the United States, and gives items which in round numbers are as follows (page 11):

|                                                    |              |
|----------------------------------------------------|--------------|
| Current maintenance.....                           | \$31 000 000 |
| Depreciation.....                                  | 45 000 000   |
| Total.....                                         | \$76 000 000 |
| Payments on account of interest and dividends..... | \$51 000 000 |

It will be seen from this statement that in addition to the expenditures for the current maintenance of the property there is a depreciation charge of \$45 000 000, which is well up toward the total amount paid by the company on account of interest and dividends. This sum of \$45 000 000 per year is compensation for the depreciation accruing during the year in the perishable property then in use. It is a much larger sum than is required for the renewal of the property units which have reached the end of their life in that year, and there is a great sum of money which can be invested in additions to the plant. The plant therefore is built up to a very considerable extent with money furnished by the rate payers, and if the property were to be valued on the basis of the cost of reproducing it, without deduction for depreciation, the rate payers, if required to pay a fair return on such value, would be paying rates on the money which they had contributed to the building up of the property. This clearly would be inequitable, and there should be a deduction for depreciation so that the value of the property would more closely represent the investment made by its owners and not by the rate payers.

In the case of large parts of a railroad property the conditions are very different, because the systems of accounting used in the past and now used to a considerable extent are based on a theory which does not require the rate payer to contribute

monthly or yearly the amount of the accruing depreciation of the existing items of property. It would be inequitable in such cases to deduct depreciation from the cost of reproduction of such property.

The subject is a complicated one, and cannot be made clear in a short statement, but there can be no question that from an equitable point of view the deduction or non-deduction of depreciation must depend upon the system by which the rate payers are required to contribute for the depreciation of the property.

In this connection it is interesting to note the viewpoint presented by the eminent counsel of the railroads in the brief filed before the Interstate Commerce Commission, page 163. It conflicts with the axiom which all engineers have learned in their early days, that "the whole is equal to the sum of the parts."

"The gradual lessening of the service life of a simple property, whereby there must eventually be a complete loss of its service life and its replacement as a whole, is depreciation in it; but this lessening of its service life, where it is but a part of a composite property, is not depreciation at all in the composite property."

Dr. Humphreys suggests a comparison of the fruits of individual enterprise with those of government ownership and management, and adopts a view unfavorable to government ownership. There are too many cases of successful government ownership and management to permit their indiscriminate condemnation. Such ownership and management has in general proved very successful in connection with water supplies in New England, and the Metropolitan Water Works of Massachusetts may be referred to as an instance where the results could not be approached by the same public works under private management.

The actual cost of these works to the end of the year 1915 amounted to \$42 800 000. The water is sold to the cities and towns in the Metropolitan Water District at cost, and in 1915 the total charge for interest and an adequate charge for depreciation was \$1 747 000, equal to 4.08 per cent. of the cost of the

works. In addition, there is a charge for operation and maintenance of the works of \$417 000, amounting to 19.3 per cent. of the gross earnings, which would be reduced but little, if any, under average corporate management. The total charge against the consumers was, therefore, \$2 164 000, which is only 5.06 per cent. of the original cost of the works. Such a result could not be achieved or approximated under private ownership.

MR. WEED.\* — I feel very much like making an apology to-night. In the first place I am a lawyer, and in the second place I am a regulator. After hearing this paper, I believe that both of these occupations are of questionable character. I belong to a little neighborhood club where we try to read papers to each other and discuss them, and it is one of the traditions of the elders of the club that we shall say no good of any paper. Their theory is that it is far more wholesome for the soul to meet with indiscriminate criticism than with indiscriminate praise. Of course, for that matter, Dr. Humphreys' abilities are too well-known and too conspicuous to require any praise from me.

I have the advantage of many of you because I was entrusted with a copy of this paper a day or two ago, and I had a chance to read it in cold blood without that subtle charm of personality which so often carries us along in unconscious and unreflecting sympathy with the views of one who is addressing us.

If you followed the paper in the same way that I did, I think you must have been impressed by a persistent note that the public service corporations of this country were being wronged and were suffering grievous injury at the hands of an over-developed and unwisely conducted regulation and by a false democracy. I was reminded when I read it of my childhood, when "Pilgrim's Progress" was not entirely out of fashion. It seemed to me that we had exhibited in this paper the public service corporation in the disguise of Christian, struggling over the long, toilsome, difficult road to Mount Zion. As he climbs the steep slopes of the Hill Lucre, there are two monsters ready to devour him, — Regulation and Democracy. Fortunately, however, Greatheart, in the disguise of an engineer, is also there ready to slay the monsters.

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\* Chairman, Board of Gas and Electric Light Commissioners of Massachusetts.



I do not suppose Dr. Humphreys intended a distorted or exaggerated view of the conditions which he has described, but when one sees a danger which he believes menaces and sees it keenly, I think perhaps he is very apt to give a pretty emphatic view of that danger, and not always to exhibit with the same care some other equally threatening dangers. I cannot help thinking, too, the more I hear about regulation, — and I have to hear more or less about it, — and a great many uncomplimentary views of it besides, — I cannot help thinking that there is a great deal of real misapprehension about its purpose.

I should like to say by way of introduction, though I know it is rather dangerous to generalize because the foundation for a sweeping proposition is often extremely superficial, — but, since we have heard something about the dangers of a false democracy, I should like to suggest that the continued existence of unrestrained monopoly is utterly inconsistent with true democracy. The philosophy of regulation, if I understand it, and I do not know that I do, although I have a great many instructors and some of them are present to-night, — seems to be based upon the consideration that certain evils are commonly attendant upon monopoly. These evils are so persistent and well known that we no longer have to discuss the probability of their presence. That is taken to be self-evident and rests finally on the fact that human nature is still somewhat unregenerate. And in acting upon this premise I take it that really we are merely judging others by ourselves and expecting them to do what we would probably do in their position.

Regulation is merely the means employed to check or correct the evils which we know or expect will attend monopoly. Simply because monopoly is deliberately and legally created introduces no good reason why we should not expect the same evils to be present as if it were illegally asserted. We are trying to restrain and check these evils by regulation, — restoring the equilibrium of which Dr. Humphreys has spoken. Perhaps I have too great confidence in human nature, but I believe that in the end those evils will be diminished and perhaps wholly eliminated. And I think that point of view of regulation and

its possible effect does not have enough emphasis, — is not so prominently discussed.

I suppose that those who have had any personal experience in administering regulation will be quite as quick as any to admit the correctness of some of the statements which have been made. I think we must all agree that there has been a certain tendency throughout the country to over-develop regulation. I am also in hearty agreement in believing that the federal valuation of railroads is one of the most monumental pieces of folly ever undertaken, with its principal value in sharpening the wits of those engaged in it. It may be true that it was forced upon the railroads through misguided regulation and by false democracy, but I think the railroads themselves perhaps had as much to do with it as the Interstate Commerce Commission. No right-minded person, even though he be a regulator, but desires to see the public service corporations strong and prosperous, so that they can take a black eye or a bloody nose in a bout with Regulation without suffering a mortal wound. But I dissent from ascribing all the ills of the railroads to Regulation and Democracy. Certainly we know better in Massachusetts. After all, what I am really trying to point out is that Regulation is not an end in itself but merely a means, an incident in the attempt to control monopoly. I have a strong notion, too, that the public service corporations have largely in their own control the style and fit of the clothes in which Regulation is dressed.

In spite of the danger of laying down broad propositions, I venture to say that the essence of a true democracy is the virtue of its individual citizens. My own conception of the citizens' duty is that there shall be a spirit of cöoperation rather than of hostility. Dr. Humphreys himself alluded to this. In the true democracy, each citizen must willingly assume his full share of the burden of the public welfare without conditioning his action upon that of others. In France and England, where we have heard and know more about conditions among the people of the nations at war, I think that we all have been impressed by their wonderful spirit of self-denying devotion to the common good. We might well take from it a very serious lesson to ourselves. As far as I can see, they are exhibiting the

true democracy. There can be no "slackers" in a true democracy. If the public service corporations do not fancy these monsters, Regulation and Democracy, might it not be well for them to set the example of the self-denying citizen in the true democracy? When they have become so virtuous that their virtues shall shine forth and be known of all men, Regulation will cease, and the public officials with their sometimes over-developed staffs and organizations who administer it will pass away. They only exist because certain evils exist. When those evils cease to exist, they will have no longer any reason or right to exist, and we will all be glad to see Regulation go. We are looking forward to that time.

Personally, I feel like being an optimist, pressing on as far as may be possible in the present and hopeful of the future. I heard, by the way, a new definition of an optimist the other day, which I will give you in closing. It was on the occasion of a visit to our office of a cross-eyed man. Some one suggested that an optimist is a cross-eyed man who thanks God that he is not bow-legged.

MR. SNOW.\*—I am very glad to see the absurdities and actual errors of our regulating bodies shown up as the author of the paper has done. Our regulation and control of public utilities has been at par with much of our governmental actions, federal, state and municipal. Our ultra-democracy has led into irrational situations.

Our fear of hereditary and royal privilege, born during the reign of the Stuart kings of England, has followed our race to this day, and has left us still afraid to trust continuous power in the hands of a single governing authority. The result is special commissions for nearly every administrative function, and great confusion of executive, legislative and, to some extent, judicial departments of government. The lack of an authoritative federal ministry has led to the usurpation of legislative direction by our Presidents to an extent that should shame a republic.

Our city governments have been a national disgrace for a century, but a better day is dawning. The charter lately adopted by Ashtabula, Ohio, portends, in my opinion, the most perfect

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\*Consulting Engineer, Boston.

city government that the world has ever seen, — a legislative ministry elected by proportional representation and a king appointed during good behavior.

The way that our author slams state commissions is good to hear. Their floundering is but natural, however, to their origins, their environments and their implied instructions. Their blundering attempts at railroad regulation as set forth by Mr. Alfred P. Thom in the paper show how our democracy has run wild. In a few years forward, this condition will be looked back upon with the same kind of indulgence and pity for the ignorance of our period as we feel when we look back upon the Ohio legislation which prescribed a different gage for railroads in that state from the gage obtaining in adjoining states, with the idea that the transfer of everything at the state line would create business for Ohio's citizens. The logical, and I think, inevitable solution is a unified federal control of all intra- and inter-state traffic.

The parent of governmental control of American railroads was competition between them. This led necessarily to regulation of rates, which in its turn called for valuation of the operating properties. The hardships to which the roads have been subjected are the natural outcome of the breaking in of a green team by a green driver. More settled conditions are becoming apparent, and, moreover, the suffering which stockholders and managers have experienced is slight punishment for the reckless and selfish use of their power and opportunities in the past.

Ideal regulation is not easy of practical application in the present state of human ethics. The line dividing so-called public utilities from private industries which sell their output to the public is very indistinct. The range covers all the space between agriculture and the rankest monopoly. We have industries that are wholly competitive, those which are wholly monopolistic, and those of all shades between these extremes. The problem of regulation is the simplest when applied to a pure monopoly, but in this case, even, what shall be the result aimed at by the regulating body? What is the proper objective of the operation of a public utility? The financier will say, to



return the highest dividend possible on the investment; the stock speculator will say, to alternately shrink and swell the net earnings so that the price of stock may oscillate; the altruist will say, to so handle the operation that people and goods may be transported at the lowest possible rates; the general officers may say, to bring the greatest possible glory and renown to them; the union employees may say, to give employment at the highest possible wages to the largest possible number of men; the courts say, "On the one hand, we have the plain duty of the corporation to furnish suitable and sufficient service to the public and on the other, the equally plain necessity of providing a fair return on the capital necessarily invested in the enterprise." The regulating official must contend with all these clashing interests in reaching his decision. It is no easy task.

I am interested in the author's interpretation of "depreciation." He states that the liability for subsequent renewals, erroneously called "depreciation," is not the reduction in worth as reviewed by a possible purchaser, but is the accrued liability of the owner. It is hard to see why the owner's liability should not pass to the purchaser, and, if it does, why it should not decrease the worth, as compared with value new, by the amount of the liability. The fact is, there are two fallacies covered in the statement; first, the capitalized prospective net earnings modified by the physical condition of the property above or below normal condition, measures the amount that a purchaser will pay, and hence deferred maintenance and not depreciation is what he inspects; and, second, the cost of renewals is a liability of the public and not of the owner. If the said cost is not charged for until the item is renewed, or if an annuity only is charged which kept at interest will amount to the cost of the item at the end of its life, the owner is simply waiting for the payment of his principal like the holder of a promissory note, and in these cases nothing should be deducted from value new when computing present value. If, on the other hand, annual sums have been charged for depreciation, and have been met by the earnings, which aggregate the full value of the item considered, then the accrued returns for depreciation should be

deducted. The matter of deduction is simply a question as to whether or not the owner has been paid accruing depreciation in a way that he can use as wholly his own, or whether it is held in escrow by the public or a trustee until the passing of the item. This is the crux of the whole science of depreciation.

MR. THOMPSON \* (*by letter*). — The writer was interested to hear the paper on "Reform and Regulation" as coming from one with extended experience in the management of public service corporations. However, disappointment in the address must be expressed, as it presented no constructive plan and gave so few suggestions of a constructive nature. Starting out with the proposition that, "on the one hand, quasi-public corporations should be required to submit to regulation under government authority," the author neglects, it appears, to treat this phase of the subject, but confines himself to a statement of the ill-effects of over-regulation. He states as the two fundamental conditions which limit the regulation of our public utilities that the initiative of the corporations should not be destroyed and that public service commissions should not be permitted to exercise the three functions of government. Assuming that this be true, what is the foundation of the public service corporation, and how should it be exercised?

The author brings out many very true points with reference to unfair treatment of corporations and biased commissioners. From the standpoint of one associated neither with municipal work nor with public utility service, it would appear that the very fact of monopoly implies the necessity for regulation. The spirit of the public during the last two or three years has undoubtedly been too severe, but, as is practically acknowledged by the author, this was brought upon the public service corporations by the action of certain of their number, and there is at least a question whether the number of these was comparatively few or whether the tendency was not widespread. Until human nature is changed, until we have a control of business based not on money returns but on the Golden Rule, we cannot expect groups of men with private interests to work directly for the interests of those to whom they are selling their product. It

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seems scarcely logical to take the position at least implied by the author of "Hands Off."

If a regulation, then, is necessary where monopolies are in operation, how shall this regulation be applied? How shall we have the coöperation between the two parties, as suggested by the author? What shall be the basis for regulation? What rules for capitalization (to which I see no reference in the paper) shall be evolved? On what basis and by whom shall rates be determined? These are pertinent questions, and it is to be hoped that Dr. Humphreys in his closure will present constructive suggestions on reform and regulation.

DR. HUMPHREYS.\*—I would like to repeat the first paragraph of my paper: "It is practically impossible to discuss any question of importance without being misunderstood. Those who strive to preserve the balance between two extremes are almost always sure to be misunderstood by the adherents of both extremes."

I am in the habit of saying, in lecturing to my classes (some of you perhaps think I am an educator by profession, which I am not), that if I should be speaking to a class of 85 on any open question there would be 85 different opinions as to what I had said. To-night gives another rather striking example to confirm the opinion I have held for many years. It is true that I have not been taking an optimistic view about democracy, nor have I been making any argument against democracy. On the contrary, I have been endeavoring to point out that if we are to enjoy the advantages of democracy we must pay the price; but I have said it was our duty as citizens, and especially our duty as engineers, being involved in all the activities of life, to endeavor to keep that price down to the lowest limit.

In preparing this closure I have read carefully, critically, my paper and the discussions submitted at the time my paper was read, and the written discussions submitted later. In all of this discussion I find little which has not been answered in advance in the paper itself. But, in view of the misunderstandings which are apparent in the discussions and as anticipated

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\* Author's closure.

in the opening paragraph of the paper as above repeated, I shall take up some of the points made by those who have been good enough to take part in the discussion, and I shall make an attempt, largely by paraphrasing, to remove some of the misunderstandings.

Coming down to a few of the points raised in the discussion, — I am glad to find that in the main Professor Jackson agrees with me. I do not think I can agree with him as to the evils I mentioned passing away, and that the day will come when the troubles we are now talking about will be forgotten. It is this very optimism, when carried to an extreme, that increases our troubles; we are too prone to allow ourselves to be led away by the smooth-tongued orators of the Bryan type who succeed in impressing upon the uninformed the idea that we must be intolerant of everything that is not ideal. We have got to make up our minds that conditions that are not ideal will continue to exist; *but it must be our constant effort to limit where we cannot eliminate the evil.* In my opinion, the millennium is not here, and will never come in this world. If you call that pessimism, then I am a pessimist, — but I do not believe that I am.

Professor Jackson says that commission government is young. "In certain few of the states, commission control of the public service companies has been in vogue for several decades, but in most of the states it has been a matter of but few years." He then takes the ground that some that are old are "fairly conservative," while others are "younger and less conservative." Unfortunately, my observation does not indicate that the older commissions have grown more "conservative" with age, but just to the contrary. The Gas and Electric Commission of Massachusetts is the oldest of the gas commissions, and, certainly, its practice has not become more "conservative" with its increasing years. The contrary is the fact. In some respects it is now one of the most radical of our state commissions. Furthermore, as I have indicated in my paper, *as a general proposition*, the commissions reach out for more power and become more and more arbitrary in their practice as their years increase.

With regard to those 626 000 stockholders, — and I find



my figure agrees with that of Professor Jackson, — we must not forget that with regard to the general interest throughout the United States in our industries and especially in our railroads (because it is railroad securities that are so largely purchased and held by the insurance companies and the banks) there are eleven million depositors' accounts in our banks and forty millions of life insurance policies; and that is why I made the point that it is a hopeful sign that the people themselves are beginning to be alarmed. We must hope that these depositors and these policyholders will make their influence felt if conditions become so bad as to decrease the rates of interest and increase life insurance premium rates. "Whose ox is gored?"

I am not sure that on another point I can agree with Professor Jackson in regard to the reliance to be placed relatively upon the consulting engineer and the operating engineer. Here again I am going to be misunderstood. There are consulting engineers and consulting engineers. I believe one of the troubles of the consulting engineer in his work is that he is apt to forget his experiences as a constructing and operating engineer — assuming that he has had such experiences. He must have been a constructing and operating engineer to be really a consulting engineer. I do not believe that men who are acting as consulting engineers and who have not had real practice in the management of properties and *been held responsible for the money results* are safe consulting engineers. I know we consulting engineers should constantly be prepared to resist the temptation to forget what were our responsibilities when we were held accountable for the money result. It is my experience that the administrative engineers throughout the country, who are operating the various great properties, are coming to understand more and more the money responsibility connected with the work of which they are in charge, and I believe as a class they are the most competent in that particular line, far more so than many of those who advertise themselves as consulting engineers.

With regard to the work before the public service commission, what I have been objecting to is not the good work that has been done. Of course not. It is the unfairness that is so much in evidence. I have, just as Professor Jackson has said

he has, intense sympathy with the man who is trying to-day to do his work under the conditions — the tremendously difficult conditions — under which a public servant has to work. I know some men to whom I look up with the utmost respect for the work they have done in that capacity; but what I object to — and I say that it is not only our right but our duty to object to it — is the unfairness and lack of judicial quality exhibited in the acts of many individuals connected with the public service commissions, and not unfairness through accident but through deliberate intention; and I make this charge knowing that it cannot be fairly refuted by those who have had personal experience in commission hearings; and I say again that I have the utmost sympathy with those exceptional men who have done their full duty in the face of bad examples.

Professor Jackson expresses the opinion that if the public service commissions do not accomplish what is fair to corporations and public "they will be swept away." I find little encouragement for this optimism in the records of our politicians.

With regard to Mr. Weed's remarks, there is not a word in my paper which shows that I have the slightest disrespect for the profession of the law as such. On the contrary, I have stated that every commission should have at least one member who is thoroughly up in the profession of the law: but there are lawyers and lawyers. I do believe, however, *that the profession of the law is over-represented in these commissions*. My advice to our young men about to graduate (and we give them some instruction on partnership and commercial law) is that they should use their necessarily superficial knowledge of law in finding out what to avoid, and also to make them extremely careful in the selection of their lawyers.

I believe — and I know I am not speaking from prejudice — that in very many cases the corporations have been greatly wronged in the decisions and opinions of the commissions.

With regard to regulation and democracy, I believe absolutely in both. Apparently I am understood as not believing in either, because I point out evils to be avoided as far as possible. As to the weaknesses in regulation by commission, I do not believe I have exaggerated in a single instance. I could

give cases so much worse than those I have cited that you would be justified in thinking I was exaggerating. Mr. Weed refers to the dangers of unrestrained monopoly. I do not think there is such a danger, because there is no apparent chance for unrestrained monopoly in this country, — certainly not with regard to public utilities. There never was unrestrained monopoly on the part of public service utilities before the day of regulation save in most exceptional cases. On the contrary, there was the widest and most reckless competition. Take for instance the little town of Yonkers; at the time when there were only 15 000 inhabitants, there were four independent gas companies fighting each other for the small business there to be found. New York was one great field of competition, so was Baltimore, and it was the same all over the United States. That was our trouble. The public and the investors have suffered more from *competition encouraged by our politicians* than they have from monopoly. "Human nature is unregenerate." That is the point I have been making. Mr. Weed and I agree on that, and it is because it is unregenerate that we have to bear it in mind so that we shall do our best to regenerate it. But we are not going to do it by listening to those enthusiasts who tell us that in a few years we shall eliminate the present weaknesses and evils of regulation as generally practiced. It is for us to face the fact that the present tendency is to exaggerate the evils of which I have spoken. One natural corrective of monopoly on the part of public utilities is the competition among themselves which continues to exist and must so continue. For instance, the competition between manufactured gas, natural gas, and electric light. In one city in New York State there is the most active competition between the three companies furnishing these three lighting services. As president of one of these companies, I know whereof I speak. This competition would exist, regulation or no regulation. The trolley lines now have active competitors in the jitneys, and so it ever will be. I have seldom met a commissioner who would admit that such competition has to be reckoned with.

Mr. Weed says there has been a tendency to over-regulation. I certainly agree with him there. That is my text. There has been a great and increasing tendency toward over-regulation, and

this is threatening the very life of our public service corporations to-day. Professor Jackson, on the other hand, apparently thinks that conditions are improving in the application of regulation by commissions. I wish I could agree with him, but I cannot. I can see no hope for improvement so long as the tendency is towards over-regulation by placing more and more power in the hands of the commissions as to *details of management*. The first remedy is to limit the powers of the commissions so that they shall not exercise authority in the three functions of government, — the legislative, the judicial, and the executive. "My own conception of the citizens' duty is that there shall be a spirit of coöperation rather than of hostility," Mr. Weed said. Again I agree with him, but I believe absolutely that the corporations, now taking the average, have been far more honest and have shown a far greater spirit of coöperation in the efforts to make regulation a success than have a majority of the commissions. Let me refer to the case of a member of the Public Service Commission, Second District, New York, — the same commission to which I have referred before. This man had been successful in business, was a man of means and desirous of serving his fellows unselfishly. I testified before him a number of times and was impressed with the fact that while he wanted to be fair he was very strongly prejudiced against all corporations. From time to time I was before him throughout the five years of his term. As time went on I found that in talking to me he would express surprise that the testimony given for the corporation seemed to be fair, and that we had shown no objection whatever to bringing out the facts exactly as they were. About three months after his term expired, he was making an address in the neighborhood in which he lived and he made this statement in the most emphatic way, — that he went into office as a public service commissioner believing that the corporations were making every possible effort to deceive him and certainly were not coöperating to develop the facts; and then he said: "I am forced now to say in all fairness that as a general proposition the corporations which came before me showed a far greater inclination to be fair and to coöperate with the commission than did the representatives of the cities."



The evils to which I have referred in my paper are always going to exist to some extent, as far as I can see, and my thesis has been to keep the facts before us all the time, so we can be prepared to reduce these evils to a minimum. In my own work with the commissions I have from the first done everything in my power to make it easy for the public service commissions to develop the truth, the whole truth and nothing but the truth. I remember in one celebrated case the lawyer for the complainants had rather crude ideas as to courtesy, with the result that at first we did not get along together very smoothly. Before we got through with the case he was in the habit of coming to me to consult me as to his side of the case, and I was glad to have the opportunity to discuss the facts frankly with him.

With regard to Mr. Stearns's remarks, — Yes, regulation is necessary. Of course the liberal spirit is shown in some cases by the commissioners, — that I have said, — and a most illiberal spirit in many more cases. I do not think it does any good to bring up a few cases on either side and say that the general result is thus determined. I have guarded myself very carefully in my statements by saying there are some cases on one side and some on the other. With regard to the theories of engineers, it is our business to correct those theories. I am talking to engineers, but I am not saying anything in support of the engineers *as against the commissions* with regard to these theories. I have not introduced that point except very briefly in connection with depreciation, and on this vitally important subject engineers of prominence disagree. I am objecting to the fact that the commissions in many cases go out of their way to be unfair in their consideration of the important questions brought before them for judgment. I am not objecting to honest differences of opinion on questions of theory. Let the theory be what it may, it is the duty of the commissioners to see that the testimony put upon the record is complete, — the truth, the whole truth and nothing but the truth; and I say without fear of successful contradiction that, in two thirds of the cases I have been interested in, *no such effort has been made by the commissioners*. I will go further and say that in many cases in which I have been concerned the presiding commissioner has done his best to cloud

the record. I say this fully recognizing the seriousness of the charge. There is room, and always will be, for differences of opinion, but they should be honest differences of opinion. Of course there will be testimony by engineers that cannot be supported. Otherwise we would be claiming that we are all perfect in our profession. Certainly we claim nothing of the kind. But that does not say that because some engineers advance incorrect theories the commissions should give the corporations unfair treatment. We should strive to be fair on both sides. It is for the commissioners to do their best to analyze fairly conflicting testimony. This they too often fail to do. Because certain unfair or stupid claims are made for the corporations does not give a valid reason for assuming that the corporations are unfair as a class. I would like to make one suggestion in regard to Mr. Stearns's remarks. Is it not true that the value of an inventory of a property as it exists is over-emphasized in most of the commissions? I would like to ask the engineers present who have had to do with real work, Does an inventory of existing work adequately represent the money that has been put into that work? Would an inventory of the completed subways of New York as being built to-day, after they have been built and everything was listed that you could find, — would such an inventory of plant and equipment represent the money invested in that property? Take some of the men here to-night, — gas men who have had difficulties with obstructions in the streets, — is it not true that in many cases their estimates, based upon average conditions, would not begin to pay the cost by reason of the local and special obstacles met? I know of a case in New York City of an able and conservative engineer who was imported from the West and who made his estimates on the cost of laying of pipe based upon the conditions in smaller and more open western cities, with the result that the work in New York City cost three times his estimate. And yet the schedule of the pipe would show so many feet of the several sizes of pipe, and the obstructions and contingencies would not and could not be adequately reflected in the inventory.

Mr. Stearns accuses me of "indiscriminate condemnation" of government ownership and management. The characteriza-

tion is not warranted by the contents of my paper. My point is that, as a general proposition, — exceptions rather serving to prove the rule, — government ownership and management in this country is not as efficient or economical as private ownership and management. The one case cited by Mr. Stearns has the earmarks of an exceptional case. But even in this case we are not told that any allowance is made for the taxes which would be paid into the public treasury under private ownership and which are lost to the government under public ownership. I have examined in detail the accounts of not a few government-owned properties which made an admirable showing until examined competently. The result of such examination in *every case* in my experience showed that the comparison with privately owned properties was unfairly made. In not a few cases, this examination showed gross misstatements of the facts. This may to a great extent be covered by the one word, — politics. Certainly, with those who have had any real experience throughout the country, with the financial operations of politically governed undertakings, it should not be necessary to say much in support of my position. If there are any not convinced, I can only say: Go out and get a little more experience, sad experience, with politicians.

I am glad to note that Mr. Snow agrees with me as to "the absurdities and actual errors of our regulating bodies." With Mr. Snow I am willing to hope for better things, and especially through unified control. Just how unified control can be secured in the face of state rights, I confess I am unable to see. We are not likely to secure better results by entertaining a pleasant belief to that end while we should face the fact that the commissions are usurping more and more power in connection with the should-be-independent three departments of our government.

In regard to "depreciation," I am sure Mr. Snow has misunderstood me, and the fault is partly mine for attempting to discuss such a difficult subject in so few words. But the little I have said might well be read again, and particularly as to the differentiation between a "reserve . . . to spread the cost of renewals uniformly over the years of service" and "real de-

preciation of plant . . . the plant in meantime being maintained thoroughly."

Mr. Snow quotes me as saying, "He states that the liability for subsequent renewals, erroneously called 'depreciation,' is not the reduction in worth as reviewed [viewed] by a possible purchaser, but is the accrued liability of the owner." Mr. Snow then goes on to say, — "It is hard to see why the owner's liability should not pass to the purchaser." Of course it passes to the purchaser, if the property changes hands. The purchaser will trade on the amount to be deducted from the purchase price new because of the liability he assumes, and, if he is wise, he will not accept without careful examination the seller's estimate of accrued liability for plant not yet to be renewed. Particularly should the estimates on accrued liability for future renewals not be based upon tables and mathematical computations. Only by *competent* examination in detail can the remaining life of the parts of a plant be estimated with any degree of accuracy. It is unfortunate for our profession that not a few engineers have encouraged accountants and commissioners in the belief that such estimates can be made by reference to textbooks and the employment of average figures. Such practice may be mathematics, but it certainly is not common-sense. There is no line of work in which experience as constructor and operator is more necessary. How can a textbook giving *average* figures instruct one as to operating conditions in a particular plant, conditions which may so vary as to make it absurd to assign the same life to two boilers of the same type, delivered from the works at the same time? I have assumed that there is no deferred maintenance, in the sense of renewals and repairs not made when they should have been made. In the statement which Mr. Snow has quoted from my paper, I intended to make the point that this assumption of liability which a possible purchaser would regard as a reduction in worth or value, and hence to be allowed for in the price to be paid, should not be the view-point of the commission in connection with a rate case involving the problems of investment and present value. If the property were sold, the liability to renew the plant would still rest upon the owners, whoever they might be.



So much for the first of the "two fallacies" which Mr. Snow has discovered in my statement. The second "fallacy" seems to be based upon Mr. Snow's contention, that "the cost of renewals is a liability of the public and not of the owner." I presume Mr. Snow bases this rather radical proposition on the assumption that the cost of renewals is to be included in the rates for service. Then why not deduct for all charges on account of maintenance, including current minor renewals and repairs as well as the renewal items included in the estimate of renewal reserve? Again, suppose the rates are not sufficient to cover total maintenance and a fair return, who is liable then? Those of us who have operated public utilities know to our cost that the rates are too often insufficient in this regard. Particularly is this so in the early years of such enterprises; and, generally, it is getting to be harder and harder to induce the commissions to acknowledge that the rates ("the public") should bear this full cost.

As I understand Mr. Snow, he agrees with me that renewal reserve should *not* be deducted "if an annuity only is charged which kept at interest will amount to the cost of the item at the end of its life." There goes the other fallacy, for, I hold, that is *the* way a renewal reserve should be estimated and maintained. This does not preclude carrying a further reserve for contingencies; but that is another story.

If Mr. Snow and others are interested in my views on this most important and much misunderstood subject, I refer them to some of my other papers as follows:

"Depreciation: Estimated and Actual." Presented before Institution of Gas Engineers (Great Britain), 1913. Reprinted in U. S. in *American Gas Light Journal*, September 15, 1913, and also in pamphlet form.

"In Rate-Fixing by Commission, Should 'Depreciation' be Deducted from Plant Valuation?" Presented before American Gas Institute, October, 1914. Reprinted in technical journals and in pamphlet form.

"Discussion of the Report of the Special Committee of the American Society of Civil Engineers on Valuation of Railroads and other Public Utilities for Rate Making." *Proceedings of A. S. C. E.*, August, 1914, page 2013.

This subject is also discussed in many other of my papers, including the paper entitled, "Public Utilities," presented before the International Engineering Congress, San Francisco, 1915.

Mr. Thompson finds fault with my paper (and Professor Jackson expresses regret) because in it I give "so few suggestions of a constructive nature." Even if that were a fact, I should not feel that it were necessary to make any defense, for an accurate diagnosis should precede an agreement as to the most effective remedy. This discussion furnishes an illustration, for certainly we engineers have not come to an agreement as to the diagnosis.

But I have ventured to make some rather important "constructive suggestions"; one being that the scope and authority of commission control be reduced rather than extended and increased. Especially I suggest that the commissions be not allowed to exercise the three functions of government, which by our written and unwritten law, endorsed by party platforms, should be kept separate and apart. In this connection, as showing that the party now in power does not consider this a dead letter, I have quoted from the 1912 Baltimore platform of the Democratic party. If this is a sincere expression of principle, let the activities of the commissions be confined to legislative functions. Certainly let them be debarred from exercising executive or judicial functions. Until the commission statutes can be amended, I suggest to the commissioners, even if they are not naturally inclined to be judicial, that they at least endeavor to cultivate a desire for ordinary fair play, and so, during the hearings at least, give to each side equal opportunities to develop the facts. I would further suggest that if they find themselves unable to go so far — namely, to abstain from such indecorous exhibitions of partisanship during hearings — that they at least refrain from side remarks with their associates and assistants, intended, apparently, to indicate contempt or amusement in connection with the testimony being offered by the witnesses for the corporations.

Since I delivered my address, I have been attending at a hearing where the commissioner conducting it was guilty of flagrant misbehavior of the character I have just indicated. That it may not be thought that I am influenced by personal feeling in these criticisms, I will say that I am confining my statements to cases in which I have been an observer and not an actor.

In view of our pronounced liking for the multiplication of laws, I hesitate to make any suggestion in that direction; but I would suggest the amending of existing public-service commission laws by relieving these commissions of all authority and all responsibility in connection with the executive and judicial departments of government. There need be no fear that cases for regulation would then not be brought before the commissions in the absence of their initiative as executives, for complaints are easily formulated by the ratepayers under the laws in force. No matter how efficiently and courteously a public service corporation may, in the main, be serving its customers, a disgruntled busybody, assisted by a lawyer on the lookout for a fee or political preferment, will find no difficulty in securing ninety-nine signatures to a complaint, to be added to his own to make the hundred; and many of the ninety-nine signers will not feel that it is necessary even to read the complaint. By throwing this burden upon those who are dissatisfied, a great saving could be effected for the benefit of the taxpayers at large who are not directly interested and yet are obliged to pay for the large and expensive organizations of our commissions. The sums spent annually by some of these commissions, the members of which are so keen in the interest of reform as applied to others, is nothing short of a scandal.

I admit that Mr. Thompson and others agreeing with him may be warranted in claiming that some of these are not suggestions of a constructive character, for the politicians and the reform enthusiasts would not permit such simplifications of the law. Certainly the professional politicians, except under pressure from the voters, would not permit any changes in the laws which would decrease the number of salaried offices, many of them sinecures.

Then the next best suggestion that I can make is that we engineers make a serious effort to learn the facts as to commission regulation as now practiced in this country, and, having learned the facts ourselves, that we do our best to educate the public and particularly the *honest* reform enthusiasts. But it appears to be evident that we engineers as a class are not yet in a position to so educate others, for we disagree among ourselves.

May I suggest to Mr. Thompson that he read again my paper, paying particular attention to the opening paragraph. If he will do this I think he will find that I have not said nor in any way implied that the government, through the commissions or any other legally constituted agency, should keep "hands off" from the corporations.

On the questions involved in regulation by commissions, and particularly as to "rules for capitalization," I would refer Mr. Thompson and others to a paper entitled, "Public Service Commissions," written by my partner, Alten S. Miller, for the 1912 meeting of the American Gas Institute, printed in the Transactions of the institute. This paper might well be studied by all interested in the impartial administration of the law, and particularly as applied to the public utilities.

In this connection and in conclusion, in view of the loose ideas held by many on this subject, including some members of the legal profession, it may be timely to point out that the courts, including the U. S. Supreme Court, do not have the power to fix rates for service. If the legislative authority has fixed a rate which in the opinion of the court is confiscatory as failing to afford a fair return upon the present fair value of the property involved in the service, the court can make void the action of the legislature. This, of course, means that our courts do not afford us complete protection against the vagaries of our commissions, and particularly so when we bear in mind that many cases which should be appealed to the courts are not so appealed through lack of confidence in the courts, through considerations of policy, and fear of the expense.

If the responsible representatives of our public utilities would unanimously decide to coöperate in every fair way with the commissions, and then to fight to the farthest limit for their rights, I believe we would be on the way to better conditions, for not only would the public then be educated, but the commissions and the courts would receive most needful education.



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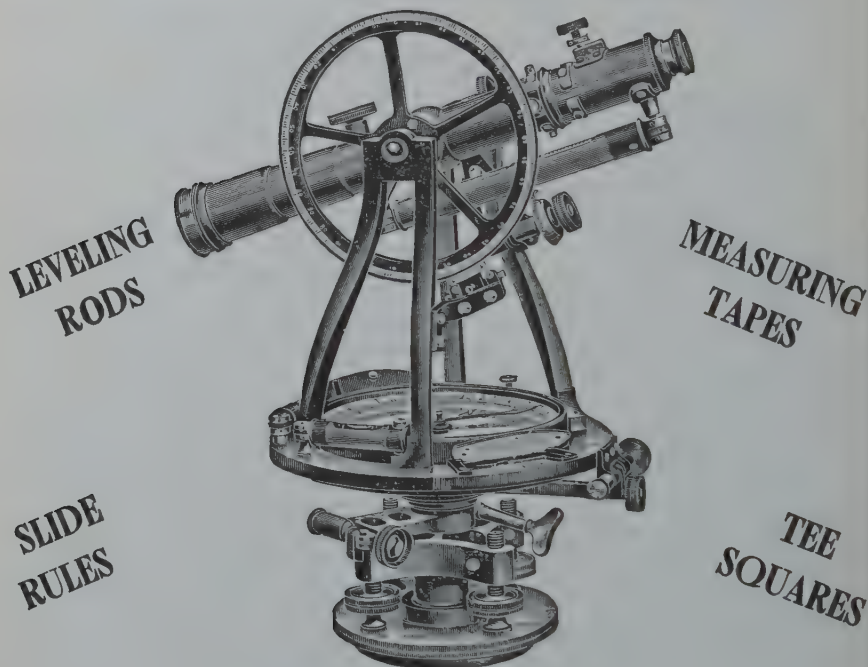
## INDEX TO ADVERTISERS.

|                                                                            | PAGE  |
|----------------------------------------------------------------------------|-------|
| A. B. SEE ELECTRIC ELEVATORS, 111 Devonshire St., Boston.....              | XVI   |
| ABERTHAW CONSTRUCTION CO., 8 Beacon St., Boston.....                       | XV    |
| ADAMS, H. S., 108 Ames Building, Boston, Mass.....                         | IV    |
| ASPINWALL & LINCOLN, 3 Hamilton Pl., Boston.....                           | IV    |
| ASSOCIATED ARCHITECTS PRINTING & SUPPLY CO., 144 Congress St., Boston..... | XVII  |
| BAY STATE DREDGING CO., LTD., 247 Atlantic Ave., Boston.....               | X     |
| BISHOP, J. W., & Co., 683 Atlantic Ave., Boston.....                       | XI    |
| BLAIR, ISAAC, & Co., INC., 433 Harrison Ave., Boston.....                  | XI    |
| BOND, HAROLD L., Co., 383 Atlantic Ave., Boston.....                       | XIV   |
| BUSS, EDWARD A., 85 Water St., Boston.....                                 | IV    |
| COLEMAN BROS., 1 Marginal St., Chelsea.....                                | XIV   |
| DETROIT GRAPHITE CO., 94 Milk St., Boston.....                             | XVII  |
| DIXON CRUCIBLE CO., Jersey City, N. J.....                                 | XVII  |
| EASTERN BRIDGE AND STRUCTURAL CO., Worcester.....                          | XVI   |
| FAY, SPOFFORD & THORNDIKE, 308 Boylston St., Boston.....                   | IV    |
| FORT HILL PRESS, 176 High St., Boston.....                                 | XVI   |
| FULLER, GEORGE W., 170 Broadway, New York.....                             | IV    |
| GOW, THE CHARLES R., Co., 166 Devonshire St., Boston.....                  | XIII  |
| HALL, JOHN G., & Co., 114 State St., Boston.....                           | XVII  |
| HARRINGTON, EPHRAIM, 20 Pemberton Sq., Boston.....                         | IV    |
| HERN, J. L., ENGINEERING CO., 149 Pearl St., Boston.....                   | IV    |
| HERSEY MFG. CO., South Boston.....                                         | XVIII |
| HOLBROOK, CABOT & ROLLINS, CORPN., 6 Beacon St., Boston...                 | VII   |
| HOLZER, U., 25 Bromfield St., Boston.....                                  | X     |
| HUGHES, EDWARD F., 8 Oliver St., Boston.....                               | XVII  |
| JACKSON, D. C. & WM. B., 248 Boylston St., Boston.....                     | IV    |
| JONSBURG, F. F., Co., 733 Old South Building, Boston.....                  | XI    |
| LEDDER & PROBST, 56 Franklin St., Boston.....                              | XIV   |
| MAIN, CHARLES T., 201 Devonshire St., Boston.....                          | III   |
| MAKEPEACE, B. L., 12 Bromfield St., Boston.....                            | II    |
| METCALF & EDDY, 14 Beacon St., Boston.....                                 | IV    |
| MILLER, WILLIAM L., 71 Alford St., Boston.....                             | VIII  |
| MOSS, CHARLES E. CO., 38 Broad St., Boston.....                            | XIV   |
| NEW ENGLAND BUREAU OF TESTS, INC., 12 Pearl St., Boston...                 | V     |
| NEW ENGLAND SAND & GRAVEL CO., West Peabody, Mass.....                     | VIII  |
| OLD CORNER BOOK STORE, 27 Bromfield St., Boston.....                       | XVII  |
| PALMER, JOHN E., 1012 Old South Bldg., Boston.....                         | XVII  |

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|                                                           | PAGE |
|-----------------------------------------------------------|------|
| PENNSYLVANIA CEMENT Co., 161 Devonshire St., Boston.....  | XI   |
| PERRIN, SEAMANS & Co., 57 Oliver St., Boston.....         | XVII |
| RIDEOUT, CHANDLER & JOYCE, 178 High St., Boston.....      | XIV  |
| ROCKPORT GRANITE Co., Rockport, Mass.....                 | VI   |
| ROURKE & SHERMAN, 6 Beacon St., Boston.....               | IV   |
| SIMPSON BROS. CORPN., 166 Devonshire St., Boston.....     | VI   |
| SMITH, B. F., & Co., 60 Federal St., Boston.....          | XIV  |
| SPAULDING PRINT PAPER Co., 44 Federal St., Boston.....    | XIII |
| STONE & WEBSTER, 147 Milk St., Boston.....                | IX   |
| THOMPSON, SANFORD E., 141 Milk St., Boston.....           | IV   |
| THORPE, LEWIS D., 201 Devonshire St., Boston.....         | IV   |
| TUCKER, EDWARD A., Co., 683 Atlantic Ave., Boston.....    | VI   |
| WALDO BROTHERS, Boston.....                               | X    |
| WARREN BROTHERS Co., 142 Berkeley St., Boston.....        | XII  |
| WARREN FOUNDRY AND MACHINE Co., 111 Broadway, New York... | VIII |
| WESTON, ROBERT SPURR, 14 Beacon St., Boston.....          | V    |
| WHEELER, CHARLES D., 65 Kilby St., Boston.....            | XIII |
| WHITMAN & HOWARD, 220 Devonshire St., Boston.....         | V    |
| WOOD, R. D., & Co., Philadelphia.....                     | VIII |
| WORCESTER, J. R., & Co., 79 Milk St., Boston.....         | V    |

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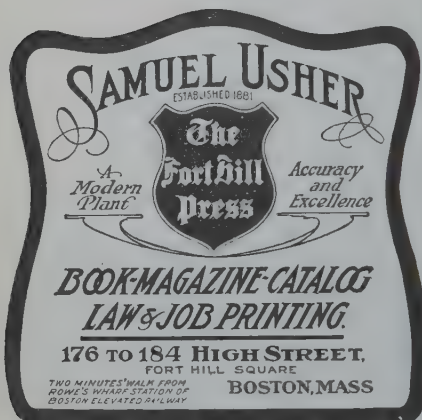
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